Utah Historic Bridge Inventory: Volume 1

Historic Bridge Context, Statehood – 1965

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Table of Contents

Page

List of Acronyms .... **iv**

1. Methodology **1**

2. Project Purpose **3**

3. Utah Highway and Bridge Development, Settlement-1945 .... **4**

A. Early road and bridge building, settlement-1909 4

B. Promotion of road development in Utah 6

(1) The Good Roads Movement 6

(2) Trails and road associations in Utah 8

(a) Lincoln Highway Association 8

(b) Midland Trail Association 10

(c) The Arrowhead Trail Association 11

C. The role of the federal government and the Federal-Aid National Highway Acts 12

(1) The Great Depression and highway and bridge construction 13

(a) Federal Emergency Relief Administration (FERA) 15

(b) National Industrial Relief Act (NIRA) 15

(c) Works Progress Administration (WPA) 15

(d) Civilian Conservation Corps (CCC) 16

(2) Preparations for World War II 16

D. Utah's prewar policies and programs 19

(1) Utah State Road Commission 19

(a) USRC staff 21

(2) Utah highway legislation and funding 23

(a) Role of contractors 25

(3) Establishment of State Primary Routes and U.S. Highways 26

(4) USRC bridge design and engineering 28

(5) City and county roads 35

(6) Achievement of long-term transportation planning goals 36

(a) Grade separations at railroad intersections 36

(b) Road surface improvements 37

(c) Road connections to bordering states 38

(d) Access to scenic areas of southern Utah 40

4. Utah Highway and Bridge Development, 1946-1965 .... **42**

A. Federal-Aid National Highway Acts 42

B. State funding, policies, and construction programs 43

(1) Utah highway legislation and funding 43

(a) Limited access roads and right-of-way ... 43
(b) Funding state highways and developing revenue ... 44
(2) The Utah State Road Commission ... 44
(3) State highway programs and implementation efforts ... 46
(a) The role of consultants and contractors in Utah's road and bridge-building efforts ... 48
(b) Expressway design and construction ... 49
(c) Interstate development in Utah ... 52
(d) United States and State Primary Route Highways ... 55
(e) City and county roads ... 57
(4) State economic development and road and bridge construction ... 58
(a) Reclamation-related transportation projects ... 59
(b) Transportation and mining efforts ... 60
(c) Transportation and the U.S. missile program ... 61
(d) Road safety improvements ... 62

5. Bridge Design and Construction ... 63

A. Influence of national design standards for bridges ... 63
(1) Bureau of Public Roads ... 63
(2) American Association of Highway Officials ... 66
(3) American Concrete Institute ... 69
(4) Prestressed Concrete Institute ... 69

B. The Utah State Road Commission ... 70
(1) Standard bridge specifications and plans ... 70
(2) Materials and testing ... 72

C. Bridge materials and types ... 73
(1) Reinforced and prestressed concrete ... 73
(a) Reinforced concrete ... 74
(b) Prestressed concrete ... 74
(c) Concrete rigid frame ... 77
(d) Reinforced concrete and prestressed concrete beams (including slab, I-beam, T-beam, and box beam) ... 79
(e) Concrete deck arch ... 87
(f) Concrete culvert ... 89
(2) Metal (iron and steel) ... 91
(a) Steel connection methods ... 92
(b) Steel beam and girder ... 95
(3) Concrete and steel beams and girders – continuous and composite design ... 98

(a) Steel arch ... 99
(b) Steel truss ... 101
(c) Steel rigid frame ... 105
(d) Steel culvert ... 106
(4) Timber ... 108
(a) Timber multi-beam beam or girder ... 109
(b) Timber slab ... 110
(5) Tunnels ... 111
D. Aesthetics in bridge design ... 111
Bibliography ... 117

Appendices

A Fraser Design’s Study of Utah Bridges Built Prior to 1946

B Glossary of Basic Bridge Types and Terms

Tables

1 BPR Standard Plans (1956) ... 65

2 Bridge Types with USRC Standard Plans ... 71

List of Acronyms

AASHO	American Association of State Highway Officials
AASHTO	American Association of State Highway and Transportation Officials
ACI	American Concrete Institute
AEC	Atomic Energy Commission
AISC	American Institute of Steel Construction
ASCE	American Society of Civil Engineers
ASTM	American Society for Testing and Materials
AWS	American Welding Society
BPR	Bureau of Public Roads
FHWA	Federal Highway Administration
I-	Interstate
NHPA	National Historic Preservation Act
PCI	Prestressed Concrete Institute
PRA	Public Roads Administration
SAFETEA-LU	Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users
SAW	Submerged Arc-Welding
S.R.	State Primary Route
UDOT	Utah Department of Transportation
U.S.	United States Highway
USRC	Utah State Road Commission

1. Methodology

The Utah historic bridge context discusses the development of bridge and culvert design and construction in Utah from statehood through 1965 provided in Sections 3 and 4.[1] Section 3 of the context builds upon a previous historic overview completed for the Utah Department of Transportation (UDOT) covering Utah bridge history from settlement to 1945, completed by Clayton Fraser, which is included in Appendix A.[2] UDOT requested Mead & Hunt to expand the pre-World War II bridge study prepared by Fraser. The prewar context incorporates information provided in the historic overview by Fraser and supplements this information with additional material regarding state and federal transportation funding, the founding and development of the Utah State Road Commission and the major trends in bridge and culvert construction in the period prior to World War II. The historic overview identifies historic themes to assist in the identification and evaluation of bridges for eligibility for listing in the National Register of Historic Places (National Register). To accomplish this, the historic context identifies national and statewide events and trends in roadway development, bridge design, and construction, and provides descriptions of the physical features of bridge types based on national trends in bridge building and an analysis of bridge types in Utah through 1965. The historic context is based on research conducted at UDOT, the Utah Department of Administrative Services Division of Archives & Record Services (Utah State Archives), and the University of Utah Marriott Library in Salt Lake City. The context provides information on national transportation programs and policies, federal law and funding, and trends in bridge design and materials. In addition to the sources listed, the context incorporates relevant information from studies conducted by Mead & Hunt in other states including Texas, California, and Indiana.

Research included primary and secondary sources related to transportation history and bridge construction and design nationwide and in the state of Utah. Key sources for the contextual study include the following:

- Biennial Reports of the Utah State Road Commission (USRC)
- City and regional planning transportation studies, including the *Salt Lake Metropolitan Transportation Study*
- USRC design manuals, including *Utah Standard Specifications for Road and Bridge Construction*
- Historic state maps showing transportation development

[1] Bridges are defined as structures with spans greater than 20 feet by the Federal Highway Administration (see *Recording and Coding Guide for the Structure Inventory and Appraisal of the Nation's Bridges*, U.S. Department of Transportation, Federal Highway Administration, Office of Engineering, December 1995). Structures with spans less than 20 feet are not included in the National Bridge Inventory (NBI). This project includes culvert structures greater than 20 feet defined as culverts and included in the NBI. Culvert bridge design is typically distinguished by the use of underfill to carry the roadbed. The earliest extant bridge under UDOT jurisdiction dates from 1908. As such, the context focuses on developments in twentieth century transportation.

[2] Clayton Fraser, "Historic Overview," 1997. Also available at Utah Department of Transportation, Salt Lake City, Utah.

- Utah Federal-aid Road System Reports
- USRC publications “Highways and Byways” (1958-1962) and “Utah Highway Progress” (1958-1961)
- *A Context for Common Historic Bridge Types* (Parsons Brinkerhoff and Engineering and Industrial Heritage, 2005)
- National engineering journals, including *Engineering News Record, Public Roads, Prestressed Concrete Institute Journal,* and *American Society of Civil Engineers Journal*
- National transportation histories, including Bruce Seely’s *Building the American Highway System*, 1987
- National engineering standards and specifications, such as those developed by the American Association of State Highway Officials (AASHO), later named the American Association of State Highway and Transportation Officials (AASHTO), and the Bureau of Public Roads (BPR), later named the Federal Highway Administration (FHWA)
- UDOT Bridge inventory data
- Ezra Knowlton, *History of Highway Development in Utah*, Utah Road Commission, 1967
- Clayton Fraser, “Historic Overview,” 1997, available at Utah Department of Transportation, Salt Lake City,
- Thomas Alexander, *Utah: the Right Place,* 2007

The context and survey includes bridges on or crossing public roads under the jurisdiction of UDOT constructed from settlement through 1965. The context focuses on national and statewide events and trends that shaped highway and bridge construction in Utah during this period. Research on local roadway development and bridge design and construction by Utah counties and cities was not completed as part of the project.

Interstate highway development, an important historic theme, is addressed in the context. However, bridges that carry the Interstate have been previously evaluated for the National Register in accordance with Section 6007 of the *Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users* (SAFETEA-LU). In Utah, no Interstate bridges were determined National Register-eligible and no bridges were included in the FHWA’s *Final List of Nationally and Exceptionally Significant Features of the Federal Interstate Highway System*.

An analysis of UDOT’s bridge inspection database was conducted to identify bridge types for inclusion in the historic context. Results of UDOT’s bridge inspection file review and information compiled during the previous study supplement the context and discussion of bridge types in Utah.

A glossary of basic bridge types and terms is presented in Appendix B.

2. Project Purpose

The purpose of this project is to assist in compliance with major federal preservation laws and regulations that affect the management of historic bridges. These laws and regulations include the National Historic Preservation Act (NHPA) of 1966 and the U.S. Department of Transportation Act (U.S. DOT Act) of 1966. The project will also assist in complying with Utah Antiquities Act U.C.A. 9-8-404 (Section 404). Section 404 is a state law with similar requirements as Section 106 of the NHPA and pertains to state-funded projects.

Bridges eligible for listing or listed in the National Register are afforded consideration under Section 106 of the NHPA. The Section 106 process includes identifying eligible historic properties, assessing the effect of proposed actions on those properties, and developing agreements that specify measures to deal with any adverse effects. In order to comply with Section 106, appropriate consultation is required among the federal agency, the State Historic Preservation Officer (SHPO), Native American tribes, the public, and other interested parties.

The U.S. DOT Act of 1966 created the U.S. Department of Transportation, an entity with a role to coordinate and facilitate transportation programs. Section 4(f) of the Act (Title 49, United States Code (USC), Section 1653(f) and later codified in 49 USC Section 303), applies to undertakings that require the "use" of a historic site, including a bridge. Under Section 4(f), a historic site is any property listed in, or eligible for listing in, the National Register. The federal agency must ensure that the provisions of Section 4(f) are met before approving a federally-funded project. Projects such as bridge rehabilitation and replacements may be subject to Section 4(f).

The purpose of the project is to identify bridges that qualify for listing in the National Register and are subject to Section 106, 404, and 4(f) compliance. The historic context assists in understanding how bridges qualify for listing in the National Register by providing contextual information to assist in identifying areas of potential significance for bridges built during this period.

3. Utah Highway and Bridge Development, Settlement-1945

In the late nineteenth and early twentieth centuries Utah was characterized by a decentralized and insular road and bridge system that served a small, predominantly agricultural, population. The only major center of population was the Wasatch Front, a broad plateau located in the northwestern portion of the state, which includes Salt Lake City, Ogden, and Provo between the foot of the Wasatch Mountains and the Great Salt Lake. The Wasatch Front remains the state' s major center of population, which resulted in the development of a transportation system that radiated outward to connect other areas of the state and neighboring states.

During the nineteenth century road and bridge construction was financed and directed by individual counties. With small and dispersed populations, low tax revenues, and limited access to materials from outside the state, county roads remained primitive, often impassable in winter. Bridges were generally constructed of local materials, primarily timber and stone, with limited engineering and construction skills available.

Between 1909 and 1945 road and bridge-building efforts in Utah were transformed by the establishment of a centralized state transportation agency, the development of professional engineering staff and a comprehensive set of road and bridge building goals that were consistently pursued throughout the first half of the twentieth century.

This section presents a historical background on the development of transportation networks and bridge construction in Utah through World War II.

A. Early road and bridge building, settlement-1909

No extant Utah bridges date from the nineteenth century, and the earliest known extant bridge under UDOT jurisdiction appears to date to 1910.[3] As such, this section provides a summary of this period of highway and bridge development.

The first company of Latter-Day Saints (Mormons) to arrive in the Salt Lake Valley in 1847 was followed by successive waves of religious immigrants through the mid-nineteenth century. Settling first in Salt Lake City, groups of Mormon pioneers quickly spread out at the direction of the church to form colonies throughout Utah, Idaho, and northern Arizona. Establishing an integrated network of roads connecting Mormon settlements was an early priority and was institutionalized under the State Of Deseret in 1849. Among the first acts of the church-based State of Deseret was the enactment of an ordinance providing for state and county road commissioners. The ordinance established the Office of the State Road Commissioner—an official elected for a two-year term by the General Assembly to designate, survey and

[3] Utah Department of Transportation (UDOT), *Bridge Inventory Database*, 2009. UDOT provided select data fields from its PONTIS bridge inspection database for extant bridges under its jurisdiction in 2009 for use during this project. The data includes a date of construction, which was verified against available information provided in bridge inspection files reviewed during 2010. Unless noted in bridge inspection files, the date of construction was generally used for the purposes of this study.

build state roads, a charge that included the design and construction of bridges. The act also directed counties to appoint their own road commissioners. This delegation of authority to the counties for road and bridge construction and maintenance continued after Utah became a U.S. Territory in 1851. Counties continued to carry out much of the road and bridge construction and maintenance in the state for the remainder of the nineteenth century and into the early twentieth century.[4]

As a U.S. Territory, the responsibility for road and bridge building shifted from the church-run State of Deseret to the federal government, which appointed a Territorial Road Commissioner to oversee road and bridge construction and maintenance. In practice, the Territorial Road Commissioner distributed funds, but work on roads and bridges was carried out by the county road commissions. Territorial funding led to a period of road and bridge improvements prior to the construction of the transcontinental railroad through Utah in the late 1860s. Funding was appropriated for the construction of roads leading into Salt Lake City, for major roads through canyon passes, and for repair to timber bridges that were highly subject to spring washouts.[5]

The coming of the transcontinental railroad shifted federal territory funding from roads to the railroad, leaving the maintenance of roads to county and city jurisdictions that were ill-equipped to fund this effort. This shift in funding to the local level led to a general period of road deterioration during the remainder of the Territorial period. In the mid-1870s Territorial Governor George Emery complained that Utah's roads were "insufferable in summer" and "impassable during a considerable portion of the winter."[6]

The majority of bridges constructed in the nineteenth century were small spans and consisted almost entirely of timber stringers.[7] Most were constructed to span the multitude of washes, seasonal streams, gullies, ravines, and irrigation ditches that characterized the dry Western landscape. Larger bridges were generally of truss design and were executed either in timber or in iron. Timber truss bridges were fabricated using local materials and labor, while metal truss superstructures were fabricated out-of-state and the members assembled on site by local labor.[8] It was not until the early twentieth century that bridge fabricators and engineering firms specializing in bridge building were established in Utah.

Utah became a state in 1896. Between statehood and 1909, when the USRC was established, road and bridge construction and maintenance in Utah remained the responsibility of counties, as it had been under the territorial government.

[4] Fraser, 2-4.

[5] Ezra Knowlton, *History of Highway Development in Utah* (Salt Lake City: Utah State Road Commission, [1967]), 60, 67.

[6] Knowlton, 80.

[7] Fraser, 6.

[8] Fraser, 6-7.

Prior to 1909 when Utah established an independent commission to oversee statewide transportation policy and funding, the state had a limited number of state-designated routes that radiated outward from Salt Lake City. One major route extended north connecting the capital with Ogden, Brigham City, and Logan before reaching the Idaho border. Another major route extended south from the capital to Nephi where it split into two branches, one extending from Nephi south through Cedar City and St. George, the other branch traversing Sanpete, Sevier, Piute, and Garfield counties toward Kanab. These two southerly routes followed the general alignments of the later U.S. Highways (U.S.) 91 (the route of former U.S. 91 became current I-15) and 89 respectively. Only one road travelled east from Salt Lake City as far as Vernal in Uinta County, but did not cross into Colorado. No western roads connected Salt Lake City to Nevada and California. The major north-south and eastern routes ended at St. George, Kanab, and Vernal. From these towns, the graded state routes ended, turning into county roads of uncertain condition. This situation created an insular road network centered on Salt Lake City that characterized the state from the nineteenth century through the first decades of the twentieth century.[9] This period, both nationally and within Utah, is characterized by a general lack of coordination among counties, with the result that many local roads often failed to provide connections across county lines or to link major towns and county seats. Most bridges on the major routes and county roads were constructed of timber and varied greatly in condition and reliability.

Like most western states, Utah entered the twentieth century with a fragmented road system that limited the transport of goods beyond local areas and made interstate commerce, except by rail, almost impossible. However, beginning at the turn of the twentieth century, a number of national trends to improve highway development and institute national policies and standards for transportation had a profound effect on subsequent developments in Utah.

B. Promotion of road development in Utah

(1) The Good Roads Movement

Although the construction of modern roads and highways is often associated with the development of automobile travel, the earliest promoters of good roads were bicyclists, such as the League of American Wheelmen, in the 1880s and 1890s. The league produced the first modern road maps, founded the predecessors of many of today's automobile clubs, and was the first organized advocate for better roads. The National League for Good Roads was founded at a national conference of the National Grange of the Patrons of Husbandry in 1892. The National League for Good Roads published the *Good Roads Magazine* to promote its ideas, which helped spread their message. The push for improved roads was also moved along by the federal government's establishment of Rural Free Delivery mail service in 1896. Since a mail route had to be passable in all weather, the designation of a road as a mail route became an incentive for improved surfaces.[10]

[9] Knowlton, 146-147.

[10] Mead & Hunt, Inc., "Indiana Bridges Historic Context Study, 1830s-1965" prepared by the Indiana Department of Transportation (2007), 17.

The invention of the automobile and the rapid expansion of its use both ended the bicycle era and inaugurated a long-term effort to enlarge and improve the country's highway system. In 1904 there were more than 55,000 vehicles in use across the United States. In Detroit, Michigan, large-scale car manufacturing began in 1908 when Henry Ford introduced the low-priced, mass-produced, Model-T, a car the average person could afford.[11] Thanks to Ford's production methods and the inexpensive Model-T, the number of autos on American roads skyrocketed to a half million by 1910.[12]

As automotive use rapidly increased in the early twentieth century, road improvement was recognized as more than just a local problem. Increasing numbers of drivers from the city were contending with muddy and impassable roads or damaging the macadam and gravel surfaces of rural roads. Together with farmers, drivers from the city called attention to the need for rural road improvement, largely for those roads intended for horse-drawn vehicles connecting farms with towns and railroad stations. Gathering strength with advocates from automobile interests, the Good Roads Movement led to the formation of other organizations, including the American Automobile Association in 1902 and the American Association for Highway Improvement in 1910. These groups also established organizations at the state and local level to promote their good roads agenda with state legislatures.[13]

The national and state groups worked to designate, promote, and improve a network of highways. These organizations promoted their routes through published guidebooks that advertised the group's highway by offering route directions and identifying locations of tourist services and sites of interest. Two national guidebook series identifying routes throughout the country were the *Tourist Information Bureau* and the *Automobile Blue Book*. In addition to the published road and route guides, gasoline, oil, and tire companies often published state maps identifying early named highways. These state maps provided information on a variety of highways, but also served as a marketing piece and included the location of the sponsoring company's service stations.[14]

By 1902 numerous national, state, and local groups were involved in road promotion through the National Good Roads Association and its local chapters including in Utah. In July 1908 the Utah Better Roads Association held its first convention at the Lagoon Resort north of Salt Lake City with Governor Cutler as its first speaker. Utah sent a number of delegates to the National Good Roads convention in 1909 in Cleveland; a factor that led the New York Times to assert that

[11] M. G. Lay, *Ways of the World: A History of the World's Roads and of the Vehicles That Used Them* (New Brunswick, N.J.: Rutgers University Press, [1992]), 168.

[12] George E. Koster, *A Story of Highway Development in Nebraska*, Rev. ed. (Lincoln, Neb.: Nebraska Department of Roads, 1997), 7.

[13] Mead & Hunt, "Indiana Bridges Historic Context Study, 1830s-1965," 17-18.

[14] Mead & Hunt, "Indiana Bridges Historic Context Study, 1830s-1965," 18.

attendance from the "far Western States," was a notable feature of the convention.[15] In 1909 the Utah Good Roads chapter appointed a legislative committee that immediately prepared a good roads program, which they presented to the state legislature for action.[16] As a part of this legislative package, a bill was passed on March 23, 1909, that created the USRC, which is discussed below. This was the first step in establishing a new administrative structure to oversee the state's road and bridge planning and construction.

Largely absent from the list of promoters of improved road surfaces and an expanded highway network was the federal government, which had opened the Office of Road Inquiry (ORI) within the U.S. Department of Agriculture (USDA) in 1893. The federal effort focused on farmers and rural farm-to-market roads, believing that interstate transportation needs would continue to be served by the railroads that were then the reigning carriers. The alternative vision of an automobile (and truck)-dominated transportation system involving major, paved, interstate highways was not fully shared by the federal administrators, despite their own engineers' understanding of the need for improved roads for autos.[17] The role of the federal government is discussed further below.

(2) Trails and road associations in Utah

Along with the Good Road Association, which advocated for general road improvements, a number of organizations also arose to promote specific auto routes. These organizations were motivated in part by a desire to memorialize earlier trails that had facilitated exploration and settlement across the country and to direct the increasing auto traffic through specific states and towns to take advantage of the tourism and the commercial opportunities offered by a heavily traveled route. Three organizations promoted auto routes through Utah: the Lincoln Highway Association, the Midland Trail Association, and the Arrowhead Trail Association.

(a) Lincoln Highway Association

The Lincoln Highway, developed and promoted in the early twentieth century, was to be a paved, toll free, and direct highway across the United States that had termini in Times Square in New York City and ended on the West Coast in San Francisco, California. Carl Fisher, an Indiana businessman and the founder of the Lincoln Highway Association, conceived of a road that would serve all who sought the most direct route from the east to the west coast. Fisher planned to call the road the Coast-to-Coast Rock Highway, but three months after he first announced his idea, he received a letter from Henry B. Joy, president of the Packard Motor Car Company. The letter not only contained a pledge of money, but it also offered an idea that would further the public's excitement and have profound patriotic appeal.[18] With the 1909 centennial of Abraham Lincoln's

[15] *N.Y Times*, "National Good Roads Convention Opens in Cleveland Tuesday," 19 September 1909.

[16] Knowlton, 130; this legislation is found in Chapter 119 (Laws of Utah, 1909).

[17] Mead & Hunt, "Indiana Bridges Historic Context Study, 1830s-1965," 18.

[18] Drake Hokanson, *The Lincoln Highway: Main Street Across America* (Iowa City, Iowa: University of Iowa Press, 1988), 11.

birthday in mind, Joy's intention was for the highway to memorialize the past president.[19] Knowing that the original name, the Coast-to-Coast Rock Highway, captured the idea of a hard-surfaced road but was not particularly inspiring, Fisher was quick to adopt the new name of the Lincoln Highway. To realize his dream Fisher called together a group of important U.S. business leaders, including members of the automobile manufacturing industry. At a dinner in March 1912 in Indianapolis, Fisher presented his plan. The businessmen knew, however, that the outcome of the highway depended not only on their own enthusiasm and capital, but also the support of the general public. Due to the overall lack of improved roads, Fisher had no problem gaining interest from the people. Soon after, his dream of building a passable route from one coast to the other became a nationwide initiative to connect the oceans.[20] In July 1913, the Lincoln Highway Association was officially organized and the elected officials announced the purpose of their organization. The statement read as follows:

> To procure the establishment of a continuous improved highway from the Atlantic to the Pacific, open to lawful traffic of all description without toll charges: such highway to be known, in memory of Abraham Lincoln, as 'The Lincoln Highway.'[21]

The Lincoln Highway, in particular, was to be an "object lesson" road, intended to demonstrate an "interstate system" at a time, around 1912, when its promoters felt that the current effort among states, local governments, and the federal government was spending too little and taking too long to produce a national road system. "Here was a start toward an adequate American highway system," wrote Austin Bement, vice president of the Lincoln Highway Association.[22]

For Utah, as for the nation, the initiation of the Lincoln Highway during the pre-World War I era represented the high point—the "most successful private roads campaign"—of the Good Roads Movement.[23] It also played a major role in ending Utah's nineteenth century isolation from neighboring states and bringing the state into the developing auto transportation network linking the country from coast to coast. The enthusiasm that Utahans had shown for the Good Roads Movement indicated that many in the state were ready to see a more effective state leadership to support improved interstate roads to link the state economically and commercially with its neighbors.

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[19] William Kaszynski, *The American Highway: The History and Culture of Roads in the United States* (Jefferson, N.C.: McFarland & Company, Inc., 2000), 38.

[20] Hokanson, 11.

[21] Hokanson, 11.

[22] Austin F. Bement, *The Lincoln Highway: Why it is, What it is, Where it is and How it is* (Detroit: Speaker-Hines Print Co., 1921), 2.

[23] National Park Service, *Lincoln Highway: Special Resource Study, Environmental Assessment* ([Washington, D.C.]: National Park Service, 2004), 32.

Unlike the federal Interstate Highway system introduced after World War II, which often constructed new roadways within newly acquired land, the named highways of the early twentieth century followed existing roads. A beginning and ending city would be designated and existing roads between the two points would be identified and continuously marked with the name of the highway. As mapped by Joy, the Lincoln Highway through Utah generally followed an existing road that paralleled the Union Pacific Railroad (UP) tracks through Echo Canyon and Parley's Canyon into Salt Lake City. Although the road followed a well-demarcated route, research found that much of the existing roadway at the time was in poor condition essentially requiring new construction.

Many of the routes designated as a part of the Lincoln Highway were undeveloped farm to market roads, little improved from pioneer days. East of Salt Lake City Joy mapped a "southern route" designed to avoid crossing the Bonneville Salt Flats directly west of the city. This portion of the route, despite some improvements, remained a daunting challenge to automobilists well into the 1930s, and was generally considered the worst stretch of the entire Lincoln Highway.[24] Despite the prevalence of ravines and dry arroyos in this area, few bridges were constructed, and the few that were built washed out frequently during the spring rains.[25] The southern route, which was located in what is now the Department of Defense Dugway Proving Grounds, was opposed by the USRC, which favored the more direct route across the salt flat to Wendover. As a result the Lincoln Highway Association funded much of the construction of the southern route. The route of the Lincoln Highway along former U.S. 40 (current I-80) from east of Salt Lake City to Wendover was also part of the Victory Highway, whose route closely followed U.S. 40 from the Colorado boarder to Salt Lake City.[26] Research revealed little information on this route and focused on the overlapping of the route west of Salt Lake City.

(b) Midland Trail Association

The Midland Trail Association was organized to promote a mid-latitude route that commenced in New York and travelled through the Midwest (Indiana, Illinois, Missouri), entering the western U.S. in Colorado and passing through Utah and Nevada to California.[27] In Utah the Midland Trail entered the state from Colorado near Cisco and travelled through Price, Colton, Spanish Fork, and Salt Lake City. From Salt Lake City westward the trail traveled north to Bringham City, to Snowville and then westward to the Nevada border. An alternate cut-off from this route at Ely, Nevada, took traffic south across central Nevada to Los Angeles.

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[24] Fraser,

[25] Fraser 31-32.

[26] "Victory Highway," http://en.wikipedia.org/wiki/Victory_Highway (accessed 5 June 2011); "Wendover Cut-Off," http://en.wikipedia.org/wiki/Wendover_Cut-off (accessed 5 June 2011); "U.S. Route 40 in Utah," http://en.wikipedia.org/wiki/U.S._Route_40_in_Utah (accessed 5 June 2011).

[27] Fraser, 29.

Like most of the trail associations, the Midland Trail Association was made up of businessmen, manufacturers, municipalities, and auto transportation boosters at both the national and local levels. In the period prior to the involvement of the federal government, the association looked to state and local units of government or commercial interests to make appropriations to improve and maintain the trail. In Utah the association had the strong backing of the powerful Salt Lake Tribune newspaper that editorialized to urge the state legislature to provide funding for highway construction and road improvement along the trail.[28] Their campaign was successful, resulting in the recognition of the route as a state highway and the appropriation of $50,000 in state funds in 1913. Construction of the highway east of Snowville commenced in 1914 with 100 miles of road completed in Box Elder County. This stretch of highway included 240 culverts, three concrete bridges, and one timber stringer bridge. The southeastern portion of the highway was constructed through Price Canyon in Carbon County and from the Green River to the Colorado state line providing the first improved road across the Utah state border with Colorado.[29] According to Utah transportation historian, Ezra Knowlton, the state's development of the Midland Trail was the first state highway work specifically aimed at improving the interstate routes and connecting Utah's roads with those of adjacent states.[30] The Midland Trail roughly followed the former route of U.S. 50 (current U.S. 6 and I-70) in the eastern portion of the state and the route of former U.S. 30 (current I-15) north of Salt Lake City to the Nevada border.

(c) The Arrowhead Trail Association

The Arrowhead Trail Association was formed in 1914 by a group of Las Vegas businessmen who sought to direct traffic through the southern Utah canyon lands and Las Vegas. The Arrowhead Trail supporters saw the potential to direct Midwestern travelers headed to Los Angeles on the Lincoln Highway and Midland Trails (former U.S. 40 and U.S. 30). Instead of the southern and northern routes around the Bonneville Salt Flats with a cut-off to Los Angeles at Ely in central Nevada, this route turned south at Salt Lake City.[31]

The route traveled along the route of the Old Mormon Trail, a wagon-era trail, from Salt Lake City south to St. George and then Las Vegas provided the antecedent of the Arrowhead Trail, which eventually became the route of former U.S. 91 (current I-15). Support for this route came from railroad interests in Utah anxious to increase tourism in southern Utah and from the well-organized tourist promotional groups in Southern California, particularly the Automobile Club of Southern California, which was quick to see the tourism potential of the more direct route between Salt Lake City and Los Angeles.[32]

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[28] Fraser, 29.

[29] Fraser, 29.

[30] Knowlton, 156.

[31] Edward Leo Lyman, "The Arrowhead Trails highway: The Beginnings of Utah's Other Route to the Pacific Coast," *Utah Historical Quarterly*, 1942, 243.

[32] Lyman, 254.

C. The role of the federal government and the Federal-Aid National Highway Acts

In 1899 the ORI (established in 1893) was renamed the Office of Public Road Inquiry and continued with technical and promotional efforts to improve roads.[33] One effort was to develop a materials testing laboratory to test samples and identify suitable road materials. In 1905 the Office of Public Roads was created by the passage of the Agriculture Appropriations Act, which terminated the Office of Public Road Inquiry and established a permanent federal road agency within the USDA with an annual budget of $50,000.[34]

In 1916 the U.S. Congress passed the Federal Aid National Highway Act, which was the first federal highway policy with regular funding appropriations distributed to the states. By this time the number of automobile registrations in the country had reached 2.3 million and the auto industry and motorists were lobbying for programs and funds to improve roads and bridges.[35] Funding had been a long-time goal of many of the named trail associations and the Good Roads Movement, who were influential in the passage of the act. Funding, managed by the Secretary of Agriculture, was allocated to each state based on the state's population, land area, and road mileage. Under this act, the Federal-Aid program would finance up to 50 percent of the cost of construction, not to exceed $10,000 per mile.[36]

Beginning with the passage of the Federal-Aid National Highway Act of 1916, federal and state governmental agencies worked cooperatively on building a comprehensive and integrated transportation system throughout the country. Over the 1910s and 1920s a complex structure of federal and state funding and legislation governed the development of highways and bridges in Utah and other states across the nation.

During the 1920s Congress continued federal funding for highway construction and amended previous legislation beginning with the passage of the Federal Aid Highway Act of 1921. This act created the Bureau of Public Road (BPR), which replaced the Office of Public Roads and was assigned to administer the federal government's road program. The act also provided financial aid to states for the construction of highways that were "interstate in character" (i.e., crossed state lines) under the "seven percent system," a formula created by Congress in which each state was eligible for assistance in constructing seven percent of its highways.[37] To participate and receive financial aid, each state was required to designate three percent of its primary roads and four percent of its secondary roads as part of the federal-aid

[33] Bruce Seely, *Building the American Highway System: Engineers as Policy Makers* (Philadelphia, Penn.: Temple University Press, 1987), 16-17.

[34] Kaszynski, 30.

[35] Seely, 24-25.

[36] Seely, 43.

[37] Richard F. Weingroff, "From Names to Numbers: The Origins of the U.S. Numbered Highway System," Federal Highway Administration, http://wwwcf.fhwa.dot.gov/infrastructure/numbers.cfm.

highway system within two years; as a result, designated roads were eligible for federal assistance.[38] Federal funding was to be matched by state funds on a 50/50 basis and designs were required to adhere to the federal government's standards for minimum width, grade, and adequacy of roadbed type for the traffic load. States were also required to submit their plans to the BPR for approval.[39]

U.S. participation in World War I (1917-1919) greatly hindered new road and bridge construction and the improvement of existing roads due to construction deferment and limited labor and supplies. World War I also raised awareness of the transportation needs that a nation at war might have and drew attention to large gaps in the national road system related to defense needs. In 1922 the Army General Staff issued the Pershing Map delineating those highways within the federal-aid system that were considered vital to national defense. In Utah this included the Lincoln Highway (which generally traveled former U.S. 30 from the Wyoming border to Echo and then along former U.S. 40, both of which were replaced by I-80), the Arrowhead Trail (which generally followed the route of former U.S 91, which was replaced by I-15), and the road that became I-70.[40] Altogether, 1,067 miles of U.S Highways in Utah became part of the national defense highways.[41]

(1) The Great Depression and highway and bridge construction

The stock market crash of October 1929 plunged the nation into a major economic crisis. As the federal government scrambled to set in place programs and policies for temporary relief of the depression and massive unemployment, it looked to transportation projects as a major form of relief activity. On November 15, 1929, President Herbert Hoover sent a message to state governors to accelerate their spending on construction projects and make new spending proposals to stop economic decline.[42] At the same time Hoover reluctantly began to implement a public works program. In 1930 and 1932 Congress passed a series of emergency appropriation measures allocating additional federal aid for state road programs.

In 1932 Hoover signed the Reconstruction Finance Corporation Act administered by Reconstruction Finance Corporation (RFC) that provided loans to states and counties to hire the unemployed. The RFC accounted for 68 percent of public relief funds expended in Utah in the year after its passage.[43] The 1932 legislation made a total authorization of $120,000,000 nation-wide with Utah's share approved at $1,395,331.[44] This funding enabled the USRC to step up its

[38] Seely, 31.

[39] Seely, 57.

[40] Knowlton, 396-401.

[41] Knowlton, 400.

[42] James J. Flink, *The Car Culture* (Cambridge, MA: MIT Press, 1975), 32-41, 155.

[43] Thomas Alexander, *Utah the Right Place* (Salt Lake City: Gibbs Smith Publishers, 2007), 315-316.

[44] Twelfth Biennial Report, 1931-1932, 14.

construction program substantially while also providing employment. The statute limited work to five days per week, with a maximum work week of thirty hours per worker, and "as far as practicable," the bill required the use of labor-intensive methods.[45] By the beginning of President Roosevelt's New Deal in 1933, Utah already had expended over four million dollars in federal relief funds.[46]

Following his March 1933 inauguration, President Roosevelt quickly instituted the first of his New Deal programs and policies, intended to stabilize the nation's economy and increase employment through greater federal spending. Utah was a major recipient of relief funding from the federal government during this era. In part this was due to the active lobbying efforts of Utah's Governor, Henry Blood, who had previously served as a Commissioner of USRC. In September of 1933 Blood travelled to Washington D.C. where he met with legislators and members of the Roosevelt administration. He brought with him a list of potential projects totaling $57 million dollars. Blood's efforts yielded Utah appropriations far in excess of its per capita share of federal funds.[47]

During the Depression era, road development in Utah and elsewhere in the U.S. was spurred through a host of new federal agencies that directly constructed or funded state public works projects.

Beginning in 1934 the USRC began implementing projects under the National Recovery Act (NRA), important federal legislation during the Great Depression. Projects implemented under the NRA were apportioned under three categories:

- National Recovery Highway (NRH) projects – for work on the Federal Aid highway system
- National Recovery Secondary (NRS) projects – for work on highways not on the Federal Aid highway system
- National Recovery Municipal (NRM) projects – for work on municipal roads[48]

In addition, NRA legislation greatly increased federal funding for road construction and maintenance beyond the usual federal-aid program. The following federal relief programs were active in Utah.

[45] Twelfth Biennial Report, 1931-1932, 9-10; Alexander, 314, 317.

[46] Alexander, 316.

[47] Alexander, 320. Harold Ickes, head of the Public Works Administration (PWA), estimated that Utah got 270 per cent of its per capital share of PWA funding due to the governor's efforts.

[48] Thirteenth Biennial Report, 1933-1934, 23.

(a) Federal Emergency Relief Administration (FERA)

Created by the Federal Emergency Relief Act of May 12, 1933, FERA was established as a program to provide unemployment relief through large federal grants rather than state loans. During its brief operation, FERA spent over $3 billion to provide relief for 20 million Americans, 16 percent of the U.S. population at the time.[49] FERA banned the use of convict labor on roadwork, which had been a fairly common practice in Utah under the USRC prior to the Great Depression.[50] In Utah FERA funds were administered by an Advisory Committee on Public Welfare and Emergency relief that worked closely with the counties to provide employment to local men.[51]

(b) National Industrial Relief Act (NIRA)

The NIRA included the largest single authorization for the nation's highways of $400 million.[52] The NIRA specified that a large portion of revenue from this source be spent on the roads outside municipalities and/or on extensions of these rural roads into municipalities. Because Utah was a predominantly rural state, this federal program was a major factor in rural county road improvement during the Great Depression. Utah was one of the first states to apply for NIRA funding and the first to place under contract a project paid for by this act.[53] In addition, the NIRA included provisions for landscaping, visual, and aesthetic improvements for highways, a fact reflected in biennial reports of the USRC, which began to note that greater attention was being given to landscaping issues, particularly in light of the dry desert conditions of much of the state.

(c) Works Progress Administration (WPA)

The Works Progress Administration was renamed to Works Projects Administration (WPA) in 1939. Roosevelt created the WPA through Executive Order in May 1935. The WPA, along with the Social Security program, was intended to replace FERA, which ended in 1935. The WPA continued until 1943.

WPA funds were matched by state or local monies. Projects funded under this program were subject to labor provisions that encouraged the state to maximize hiring. The WPA built 572,000 miles of highways, 67,000 miles of city streets, and 78,000 bridges during its existence.[54] Of all the federal relief agency work in Utah, the WPA employed the largest number of people, an

[49] Work Projects Administration (WPA), *Final Statistical Report of the Federal Emergency Relief Administration* (Washington, D.C.: U.S. Government Printing Office, 1942), iii, 2, 5-7, 53, 58, 165.

[50] Knowlton. 315.

[51] Knowlton, 316.

[52] Knowlton, 314

[53] Knowlton, 315; the first funded project was a road from Salt Lake City to Saltair, a large resort facility located on the Great Salt Lake.

[54] James S. Olson, ed., *Historical Dictionary of the New Deal* (Greenwood Press, 1985), 548-551; Seely, 90-91.

average of almost 11,000 per year from its establishment to 1942.[55] In Utah at least 53 bridges (including six grade separations) were constructed under the WPA program.[56] According to Knowlton, WPA funding of rural and municipal projects brought a new balance to the over-all highway program and marked the beginning of a sound policy of devoting federal funding to county and municipal roads that continued into the post war period. [57] Funding for WPA projects also included specific funding for grade separation projects, already a priority of the USRC.

(d) Civilian Conservation Corps (CCC)

The CCC was created in March 1933 at the outset of the Roosevelt administration. The CCC was designed to provide jobs for men between the ages of 17 and 24 whose families were already on relief. The program soon added veterans of the Spanish American War and World War I, without age restrictions. The CCC paid $30 a month and was under the administrative control of the U.S. Army. In Utah the CCC provided labor for conservation work, particularly watershed management, and National Park construction. Although most of its road and trail building efforts were conducted on federal lands for federal agencies, the program made a substantial contribution within the state to relieving unemployment.[58]

The CCC fell under the jurisdiction of the U.S. Forest Service, Soil Conservation Service, and National Park Service, although the U.S. Army organized the operation of individual group camps. Besides providing employment, education, and work experience for unemployed youth, the CCC often undertook road and trail construction on federal lands. Since Utah was a “federal land” state (a western state with a high percentage of federally-owned forest, park, and Native American reservation land), the CCC undertook a number of road and bridge projects on lands within federal jurisdiction. A small number of bridges on federal lands may have been transferred to UDOT. Federal park and forest roads and bridges that remain in federal jurisdiction are not included in this study and are more appropriately evaluated in the context of National Park Service and National Forest Service rustic architecture and engineering in the 1930s. Structures in parks and forests were generally designed and built to different standards than those of state highway agencies.

(2) Preparations for World War II

During the last few years of the 1930s, the federal government began to shift its focus from depression relief to war preparation. The Federal-Aid National Highway Act of 1939 made federal funding available for highway work deemed essential to national defense without the need for state matching funds and the Defense Act of 1941 made additional “emergency” funds

[55] Fraser, 51.

[56] Knowlton, 328.

[57] Knowlton, 327.

[58] Alexander, 322.

available.[59] Much of the work deemed "essential" was concentrated on the roads within the Strategic Highway Network and roads in and around military installations and vital defense industries. These routes were often the same ones identified on the Pershing Map of 1922 discussed above. In 1940 the Secretary of War designated the selected routes as the Strategic Network.[60]

Beginning in the mid-1930s the federal government revived and expanded existing military facilities and began construction of new facilities in the vicinities of Salt Lake City and Ogden. Among the most important were the Ogden Arsenal, Hill Air Force Base, Fort Douglas where the Ninth Command Headquarters was relocated from the Presidio in San Francisco, and the Wendover Air Force Base where the 509th Composite Group trained for their mission to drop the atomic bomb on Hiroshima and Nagasaki.[61] These bases were located within close proximity to U.S. 91 and the route of former U.S. 40 (replaced by current I-80).

By July 1940 the USRC had 183 miles of defense related road and bridgework under construction that included 50 separate projects distributed over 20 counties. This work program was interrupted by the beginning of the war in 1941 and replaced with projects identified as vital to the war effort.[62] Although the appropriation for projects vital to the war was made prior to the U.S. entry into the World War II, the money did not become available until the beginning of 1942, shortly after the bombing of Pearl Harbor.

At the same time that the U.S. was pursuing World War II defense related road programs, the federal government was looking towards the conclusion of the war and taking actions to promote and fund an active post World War II (postwar) highway program. In order to address nationwide road deficiencies that arose as a result of wartime efforts and materials shortages, a highway program was implemented through the enactment of the Federal-Aid Highway Act of 1944 (1944 Act), which expanded federal funding available for the nation's road system. The Federal-Aid road system included three types of roads: 1) Federal-Aid primary system, including U.S. Highways and State Primary Route (S.R.) Highways, which were roads designated by the states as primary transportation routes; 2) secondary system, known as feeder roads, including county roads, rural postal delivery routes, and public school bus routes; and 3) highways in urban areas. The 1944 Act increased funds for primary roads and also provided new funding for construction of urban highways and expressways and secondary roads. Previous federal aid prior to World War II focused largely on rural roads and limited the number of miles of secondary roads that could be

[59] Knowlton, 401.

[60] Knowlton, 398.

[61] Alexander, 340-346.

[62] Seventeenth Biennial Report, 1940-1942, 7.

improved with federal funds. The 1944 Act was the first time federal funding was provided for urban and secondary highways.[63]

Three categories of funding related to the roadway types listed above were established by the 1944 Act, which provided $500 million nationwide per year during the three years successive to the end of World War II, with $225 million allocated to primary roads, $150 million to secondary roads, and $125 million to urban roads.[64] This funding was distributed differently for urban and rural roads. For urban highways it was distributed by total population, while for rural highways it was distributed to the states in proportion to rural population, geographic area, and post road mileage (roads along postal delivery routes).[65]

This funding, for which the states were responsible to match at a 50/50 ratio, proved to be somewhat limited when distributed among all the states. For the fiscal year ending June 30, 1946, Utah's apportionment of federal aid monies amounted to $4,651,056, which included $2,531,450 for primary roads; $1,685,875 for secondary roads; and $433,731 for urban roads. Thus, Utah received a mere 0.93 percent of the national federal-aid allotment for fiscal year 1946. However, as a "public land state," Utah benefitted from additional federal monies for strictly federal road projects on public lands managed or owned by the Forest Service, National Park Service, and Bureau of Indian Affairs. Public land states were defined as those containing public lands and non-taxable Indian lands exceeding five percent of the total area of all state land. Other public land states include Alaska, Arizona, California, Colorado, Idaho, Montana, Nevada, New Mexico, Oregon, Washington, and Wyoming. Utah's allotment of federal monies for these projects in the three immediate postwar years included $25,000,000 per year for Forest Highways; $12,500,000 per year for Forest Development roads and trails; $14,250,000 per year for roads in or leading to National Parks or National Monuments; and $6,000,000 per year for roads serving Indian lands.[66]

The 1944 Act also allowed states to use 10 percent of appropriated federal funds to eliminate highway-railway crossing hazards on the Federal-Aid system.[67] Highway-railway crossings are also referred to as at-grade crossings where vehicular and railroad traffic cross each other at street level. Several grade-separation structures in Utah, constructed to elevate either the roadway or the railroad, were completed under this program to eliminate crossing hazards.[68]

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[63] Bruce Seely, 189-191.

[64] Nineteenth Biennial Report, 1945-1946, 23-24.

[65] Bruce Seely, 189-191.

[66] Nineteenth Biennial Report, 1945-1946, 23-25.

[67] A. E. Johnson, ed., *Published on the Occasion of the Golden Anniversary American Association of State Highway Officials: A Story of the Beginning, Purposes, Growth, Activities and Achievements of AASHO* (Washington, D.C.: The American Association of State Highway Officials, 1965), 153.

[68] See Nineteenth Biennial Report, 1945-1946, and Twentieth Biennial Report, 1947-1948.

In addition, the 1944 Act authorized designation of the National System of Interstate Highways. The Interstate system was intended to connect principal metropolitan areas, cities, and industrial centers; serve national defense; and connect border points with routes of continental importance in Canada and Mexico. The Interstate system was expected to carry 20 percent of the nation's traffic and connect 90 percent of cities with a population of 50,000 or more. The 1944 Act called for the system not to exceed 40,000 miles.[69] A drawback of the 1944 Act was that it did not provide funding for construction of the expressways and the Interstate system, but only acknowledged the designation and allowed for preliminary planning efforts. The USRC, like many highway agencies during this period, completed planning efforts for the construction of freeways and Interstate Highways, but no construction.

Although the 1944 Act provided some funding for construction of primary and secondary roads and urban highways, it did not do enough to solve the nation's transportation problems. The 1944 Act did not anticipate postwar financial prosperity, which dramatically increased automobile ownership, highway usage, and commercial development. The unexpected increase in automobile usage created congestion in many urban areas and increased pressure on the overall transportation network.[70]

D. Utah's prewar policies and programs

(1) Utah State Road Commission

The principal governing agency for Utah's highway and road system was the USRC, which was established by the state legislature in 1909. The USRC initially consisted of five members: the governor, state treasurer, state engineer, and a faculty member from both the University of Utah and Utah State University. The first task of the USRC was to delineate a state road system that would link county seats and major towns.[71] In pursuing this task the USRC undertook a major survey of existing roads within the state and required county road commissions to map their roads and provide traffic summaries to determine which roads received the most use.[72]

From its creation in 1909 through 1920 the USRC was an appointive board that served without remuneration. The heavy workload involved in policy-making and administering the state's road program took a toll on the volunteer commissioners. An important change to the USRC occurred in 1921 when the legislature made it a paid full-time body appointed by the governor. This change strengthened the USRC but made it a political body subject to the direct control of the governor. The USRC underwent another major reorganization in 1941, which is discussed below.

[69] Johnson, 153.

[70] Bruce Seely, 191.

[71] Knowlton, 138. The state highway commission legislation is contained in Chapter 19, Laws of Utah, 1909.

[72] Knowlton, 139.

Despite these various changes the USRC continued throughout the pre-World War II (prewar) period to set policy, distribute funding, and establish goals for Utah's highway, road, and bridge system.

The legislation establishing the USRC empowered it to approve plans, specifications, and estimates for road work. The legislation also divided the state into four administrative regions, the forerunner of regional administrative districts, and established testing laboratories at both of the state's universities.[73] The latter were replaced a few years later by a testing facility directly under USRC jurisdiction. The USRC also assumed control of state road funds, distributing them equally among the counties, and authorizing counties to raise additional matching funds though county taxation. In its policy setting role the USRC, early in its history established a comprehensive program that it continued to pursue throughout the pre-World War II period. Broadly this program included improving the roads and bridges throughout the state, placing the state's transportation programs on a sound financial basis, and integrating the state's internal road system into a comprehensive network, as well as connecting this system to highways and road beyond Utah's borders.

Even as the USRC was gaining organizational stability and professionalism, the agency faced stark challenges with the onset of the Great Depression. County and municipal governments also dealt with financial difficulties. While the Great Depression was marked by hardship and thrift, the period also represented a time of change and expansion for road development in Utah. Increased federal road funding and the establishment of a host of federal work-relief agencies offered the USRC an unprecedented opportunity to move forward with its programs that had been long impeded by funding limitation.

This was in marked contrast to the situation in other sectors of the state. As a predominantly agricultural state with a limited industrial sector at the time, Utah suffered severely from the national economic crisis. In 1929 Utah was already one of the less prosperous states in the country with an average income per household that was 80 percent of the national average, making Utah 30th among the 48 states in household income.[74] Between 1929 and 1933 Utahans sank deeper into poverty with a decline from an average household income of $559 per year in 1929 to $300 per year in 1933. The value of mining and agricultural goods, the state two economic mainstays, declined precipitously with many mines closing. By 1933 Utah had a 36 percent unemployment rate.[75]

Despite its management of a multitude of new and complex programs during the Great Depression years, when Herbert G. Maw took office as governor in 1941 he dramatically reorganized the USRC. Maw had run on a ticket promising to reform Utah government and the

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[73] Knowlton, 139.

[74] Alexander, 311.

[75] Alexander, 311.

reorganization of state agencies, including the USRC. Under a bill passed by the legislature at Maw's behest in March 1941 a major reorganization of the USRC was implemented, placing it under a state Engineering Commission given jurisdiction over all water and highway engineering projects.[76] Maw also dismissed the previous commissioners and appointed members of his own choosing, leading to a series of lawsuits that proved disruptive to highway administration following the reorganization. This situation continued to the postwar period when a new administration reversed Maw's policies and restored the USRC to its former independent status.

Once the U.S. entered the war, the USRC made clear that all its efforts were concentrated on the single objective of winning the war. Civilian priorities defined in previous years were put to the side to concentrate on defense related projects.[77] This was both a benefit and detriment for Utah's highways. Non-strategic road and structure improvements, replacements, and maintenance were suspended during the war years, leaving the state with an immediate postwar backlog of road and bridge work on routes not in the Strategic Highway Network. However, in some areas it proved a boon. Because most of the state's military infrastructure was concentrated in the Wasatch Front, the wartime defense priorities of the federal government dovetailed nicely with the state's planning priorities at the end of the Great Depression that proposed a rebuilding and modernization program in the state's urban areas.[78]

(a) USRC staff

During its first two years the USRC had no staff and the details of road and bridge engineering were left to the counties. This changed in 1911 when the USRC budget was increased and it was able to hire the first State Engineer, W.D. Beers. Beers began adding employees to establish a highway engineering staff to carry out the policies of the USRC.[79] Beers focused on hiring engineering, drafting, and clerical personnel and set up a permanent office in Salt Lake City.[80] In addition to the engineering staff in Salt Lake City, the USRC established Field Agents who had charge of most of the road equipment and supervised actual road and bridge construction on state routes. Hiring professional engineering staff allowed the USRC to report that the character of construction work in the state had generally been improved as a result.[81] During the teens and 1920s staff was gradually increased. By 1918 the USRC added two engineering positions to assist the State Engineer and a number of District Engineers were hired to oversee work throughout the state.[82]

[76] Knowlton, 392.

[77] Eighteenth Biennial Report, 1943-1944, 7

[78] Knowlton, 403.

[79] Knowlton, 569.

[80] Fraser, 20.

[81] Fifth Biennial Report, 1917-1918, 17.

[82] Fifth Biennial Report, 1917-1918, 11.

In the 1910s and 1920s the USRC staff became active in a number of national highway organizations, including the AASHO, the American Highway Association, and the American Concrete Institute (ACI).[83] These activities helped the USRC and its employees stay abreast of what was happening in these industries and advances in highway engineering and materials. The USRC indicated that by 1918 federal standards were being made widely available in the form of standard specifications published and distributed to staff.[84]

From 1911 until 1941 when the USRC and state agencies were dramatically re-organized under Governor Maw, the State Engineer appears to have worked directly under the USRC. As a full-time professional engineer he hired and directed staff based on monies appropriated by the USRC for that purpose. There was no transportation department that operated as a separate agency or bureaucratic entity. As the staff of the USRC grew they were organized into “departments” which functioned as “work teams” with specialized assignments based on expertise. The “Bridge Department” was one of the first designated staff groups within the overall Engineering Department (both terms are referenced in research and are used throughout the context interchangeably). By 1932 there also were Drafting, Equipment, Materials (testing laboratory), and Accounting departments.

Utah did not have a state civil service system in the prewar period and employees appear to have been governed directly by the USRC, a situation that historian Knowlton blames for high turn-over rates throughout the period. From its inception the engineering staff of the USRC experienced problems resulting from low salaries and an inadequate pool of qualified applicants. Beginning in 1941 the USRC recommended legislation that would give them independent power to establish compensation schedules in order to attract engineering professionals to the department. However, these problems were exacerbated during World War I by the demand for young men to join the war effort and again in World War II. Although in Knowlton’s view, the creation of a full-time USRC in 1921, discussed above, served to a degree to insulate staff engineers from the impact of political change, these issues were never fully resolved until well after World War II.[85]

The major government reorganization of 1941, at least in Knowlton’s view, had very detrimental effects on the operation of the USRC staff. Knowlton states that the reorganization resulted in a major turn-over of staff and severe demoralization among those that stayed. Coupled with civilian man-power shortages resulting from conscription during the war, the engineering staff remained short-handed through the mid-1940s and entered the postwar period with limited staff resources to meet postwar challenges.[86]

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[83] Knowlton, 164.

[84] Fifth Biennial Report, 1917-1918, 19.

[85] Knowlton, 205-206.

[86] Knowlton, 394.

(2) Utah highway legislation and funding

At the same time that the federal government was developing programs for financing transportation and for sharing funding with states, states were developing their own funding mechanisms and developing more elaborate sharing arrangements with counties and municipalities.

When the USRC was established in 1909 the state had contributed only limited funds to state road and building. In 1909 the entire legislative appropriation was $27,000.[87] In 1910 the combined $100,000 of state and county funding statewide resulted in only 125 miles of new road construction.[88] The lack of funding gave rise to public recognition that leadership and better highway financing would be needed to improve the state's transportation system. One of the USRC's primary goals was to increase state expenditure on transportation. Combined with public pressure from the Good Roads Movement and trail associations, the legislature responded with increased appropriations and the creation of new funding programs between 1909 and 1929. Beginning in 1911 the legislature raised the state appropriation for roads and bridges from $27,000 to $60,000, a 45 percent increase.[89] Subsequent legislative appropriations were increased annually up until the beginning of the Great Depression. During this 23-year period, the legislature authorized several new programs to raise highway revenues including bonding, vehicle licensing, and a gas tax.

In 1911, the first year the legislature authorized an increase in highway funding, it also authorized the issuance of highway bonds for $260,000 to be equally distributed among the counties for the construction, maintenance, and repair of state roads and the building of bridges.[90] Knowlton calls the period from 1911-1925 the "bond issue period," because so much of the funding for highways came from this source.[91] From the modest bond measure in 1911, subsequent bonding issues in 1917 and 1919 increased highway financial resources to $5,250,000.[92] The legislature also authorized counties to hold countywide bond issues to match state financing. Counties were quick to take advantage of this program with twenty of twenty-nine counties issuing bonds during the 1920s. Funds derived from county bonds were expended within the issuing county only.[93]

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[87] Knowlton, 139.

[88] Knowlton, 149.

[89] Knowlton, 149.

[90] Knowlton, 150.

[91] Knowlton, 197.

[92] Knowlton, 197.

[93] Knowlton, 197.

Fees and taxes also provided highway and bridge funding. In 1915 the legislature enacted a comprehensive annual motor vehicle registration law that established a substantial fee, the proceeds of which went to the State Road Fund.[94] The state's sources of highway funding were enhanced in 1923, when the legislature adopted the recommendation of Governor Charles Mabey to levy a gasoline tax of 2½ cents. The tax was raised again in 1925 to 3½ cents per gallon.[95]

As part of its initial response to the Great Depression, the state legislature in 1933 raised the gas tax another ½ cent to 4 cents per gallon to replace the county property tax funds lost as a result of adding county roads to the state system in the early 1930s, discussed below. [96] The addition of gas tax revenues placed Utah in a more favorable position to secure additional federal relief funding.[97] The gas tax increase served Governor Henry Blood well in his lobbying in Washington, impressing some federal officials with the willingness of the state to attempt to match federal funding for highway programs.[98] The gas tax provided a substantial new source of funding for highway construction and maintenance.

However, only a limited portion of gas tax monies went directly to financing highway and bridge projects in the state. By law the revenue derived from the gas tax had to be used to retire the bond indebtedness incurred with the state highway and road bonds. Any funds over and above those required for bond indebtedness could then be used for state road projects. During the 1920s much of the gas tax revenue was taken up by payments on bond debt. But in 1937 the bond indebtedness was retired, freeing the revenue derived from the gas tax to be redirected for use in county and city road projects. This provided a major new source of funding for projects within the jurisdiction of the counties and municipalities.[99]

The increase in the gas tax and the subsequent retirement of bond indebtedness after 1937 made the gas tax one of the principal sources of state highway and bridge funding in Utah from the late 1930s through the 1950s, when major changes in the Federal-Aid National Highway Act shifted the balance between state and federal funding.

In addition to raising state funding with the gas tax increase during the Great Depression, the state developed a number of its own highway relief programs that played an important role, especially in the early years of the Great Depression, in relieving unemployment and poverty in the state. Following Hoover's directive to the states, Utah's Governor advised the USRC to

[94] Knowlton, 159

[95] Knowlton, 245.

[96] Knowlton, 313

[97] Knowlton, 293-296,

[98] Alexander, 320.

[99] Fifteenth Biennial Report, 1937-1938, 72.

quickly move state highway construction projects ahead of schedule to provide as much work as possible for the unemployed. The governor also encouraged contractors to minimize the use of heavy equipment and to use hand labor in order to maximize employment opportunities.[100]

Before federal relief efforts were underway, the Utah instituted a set of non-binding resolutions to relieve unemployment through state funded projects and road contracting. The resolutions stated that preference in hiring should be given to Utah men with families, wage scales should be maintained at the level they were at time of contract signing, and that work hours per laborer should be limited to eight per day.[101] These measures provided grant funds to implement approved highway and bridge projects and allowed the continuation of projects that would have otherwise been abandoned due to insufficient matching state funds.

The most important state relief program was the “betterment work” initiative, which was financed on a 50/50 basis with counties. Through small projects the commission sought to provide at least limited employment in road and bridge work for the maximum number of men at the local level.[102] These small projects were continued throughout the Great Depression and were enhanced with redirected state funds after the federal government dropped the matching requirements on federal-aid projects.[103]

Well before the United States entered World War II, mobilization for the war began by providing crucial supplies and munitions to the European Allied forces. Domestically, funding to states, including Utah, was made available to plan the construction of major Interstate Highways that had been designated as a part of the Strategic Highway Network in 1926 and were eligible for federal funding. Utah was recognized as a vital part of the supply lines for the defense of western North American and the Pacific Rim.[104] One of the War Department’s prewar goals was to locate centers of strategic materials and supplies away from the east and west coasts where they were vulnerable to foreign attack. The Wasatch Front of Utah offered an ideal location; inland with a central location accessible by road and rail to California, Denver, and the Midwest and a concentration of population sufficient to provide a civilian work force for industry.[105]

(a) Role of contractors

During the pre-World War II period the USRC and counties relied almost entirely on private contractors to oversee and carry out road construction work. Design was the responsibility of the engineering staff and engineering services were provided by the USRC through the Field Agents

[100] Alexander, 314.

[101] Knowlton, 298-299.

[102] Knowlton, 299.

[103] Knowlton, 316.

[104] Alexander, 340.

[105] Alexander, 340.

who inspected contractor work. A number of construction contracting firms worked extensively for the USRC in the pre-World War II period. Among these firms were W.W. Clyde & Company, Gibbons and Reed, Carl Nelson, Reynolds- Ely Construction Company, Sumsion and Sons, A. O. Thorn and Sons, and L.A. Young and Company. All of these firms worked more than twenty years for the USRC, some into the postwar years.[106]

Up until the 1930s, Utah, like many states, made use of convicts in the state and penal system that were organized into road crews under the supervision of a contractor to provide labor on road and bridge projects. The use of convict labor was indicated as "State Forces" as the contractor on bridge plans. Federal-aid funding and work relief funding bills under the New Deal put an end to this practice.

(3) Establishment of State Primary Routes and U.S. Highways

Among the first duties of the USRC was the designation of a state highway system. Based on maps and traffic information provided by each of the counties, the USRC determined which roads to place within the state highway system under the jurisdiction of the state, and which to leave under local jurisdiction. In general, roads that crossed county lines fell within the jurisdiction of the state, while those that began and ended within a single county fell within the jurisdiction of the county.[107] The designated state road system established in 1910 included 3,387 miles and remained the official road system with only minor changes until 1931.[108]

At the same time that the USRC was establishing and publishing a map of the state routes in Utah, there was an increasing demand for a nationwide system of highway routes and road signs that would organize and provide clarity among the confusing jumble of named highways that had arisen after the turn-of-the- twentieth century. Groups like the Lincoln Highway or Midland Trail posted highways with identification and directional signs. These efforts did not always provide travelers with the shortest or most direct route between cities, and in some locations named trails overlapped each other. Private promoters of the named trails were also concerned that if they invested in roadway improvements, the federal government, due to the new emphasis on the role of highways in national defense that followed World War I, would "take over and complete their trail as a defense measure."[109]

Following the 1922 AASHO annual meeting and AASHO's subsequent recommendations on how to identify a national system of highways, the Secretary of Agriculture appointed the Joint Board on Interstate Highways to undertake the endeavor of designating a system of highway routes and establishing a standard system of signing the routes. Throughout 1925 the Joint Board on

[106] Knowlton, Appendix 2, Roads Constructed Contract and Utah Road Contractors, 709.

[107] Knowlton, 291.

[108] Knowlton, 165.

[109] Weingroff, "From Names to Numbers: The Origins of the U.S. Numbered Highway System."

Interstate Highways held meetings across the country to receive input on the new system of highway routes. Early on, Joint Board of Interstate Highways members agreed the system would be numbered rather than named, and would be designated as the "U.S. Highway" system rather than as the "interstate system" or "numbered Federal system of interstate highways."[110] The remainder of their work focused on identifying the routes to be designated as U.S. Highways and developing standardized signage.

By the end of 1925 a national numbering system plan was adopted for the U.S. Highways and included the standard design for signs to mark roads between states. When this plan took effect in 1926, the new numbering system affected 145 roads or 76,000 miles of road across the U.S. The uniform white shield sign had bold black text and the only variation was the number of the highways and the name of the state. The state's name was included in the top portion of the sign, and the highway number appeared in large bold text in the lower portion. Odd numbers were used for north-south routes and even numbers were assigned to east-west roads.[111]

In most cases the designated U.S. Highways followed existing named and state highway routes; for example, the Lincoln Highway was designated as U.S. 40. Several state highways that had been designated by the USRC as part of their work of establishing a state highway system in 1910 were designated as part of the newly created U.S. Highway system.[112] Roads that were both a U.S. Highway and a state highway were cosigned.

The major U.S Highways designated in Utah included the north-south roads extending from the Idaho border south to St. George and the Nevada and Arizona borders (U.S. 91 and 89), east-west routes crossing the Bonneville Salt Flats and Great Salt Lake Desert on the west and the agricultural counties of Duchesne and Uintah on the east (U.S. 40).[113] The system of state routes and U.S Highways in Utah remained unchanged until the Great Depression when economic pressures led the state to re-examine the relationship between state and country roads.

In 1931 the state legislature amended the definition of state and county roads that had previously prevailed to expand the mileage within the state's network of roads. The 1931 legislation reclassified the states non-federal roads into two categories: primary and secondary roads. Primary roads included state highways and those that were most heavily travelled within a county. This action moved a substantial mileage of county roads (674 miles) into the road system under the USRC jurisdiction.

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[110] Weingroff, "From Names to Numbers: The Origins of the U.S. Numbered Highway System."

[111] Kaszynski, 60.

[112] Knowlton, 146-147. USRC road maps indicate State Routes in dark line. These routes do not appear to have been designated with numbers. Named roads such as the Lincoln Highway, the Midland Trail, and the Arrowhead Trail were designated on the map as State Routes.

[113] State Road Commission, *Road Map of Utah*, 1940; Tenth Biennial Report, 1927-1928, 27-28.

During the 1930s the USRC placed its emphasis less on expanding the state and county road network through new construction, and more on the improvement of existing routes. Most of these improvement programs were a continuation of policies and goals formulated in the late teens and early 1920s. The more ambitious portions of this program are discussed below under policy goals and achievements of the prewar years.

During the war, highway and bridge work in the state centered on either improving or creating access to military installations or focused on road capacity to transport heavy war-related equipment and materials. Within the limitations of the wartime program, 85 highway projects, resulting in 340 miles of new roads, were completed between 1942 and 1945 in Utah.[114] Most of these improvements were concentrated in the northwestern part of the state with its heavy concentration of military facilities and defense plants. These improvements provided access to the Wendover Air Force Base, but also to the Tooele Army Depot, the Deseret Chemical Depot, and the Dugway Proving Ground.[115] The USRC completed 33 access roads to military facilities involving approximately 182 miles.[116] In addition to the road improvement projects, in 1942 the USRC continued planning work and the road survey project it began in the 1930s, which would play an important role in postwar planning for highway improvement and the initiation of the Interstate Highway program of the 1950s in the state.

(4) USRC bridge design and engineering

Prior to the establishment of the USRC, bridges were overwhelmingly financed and constructed by counties. Steel truss bridge construction relied, as indicated earlier, on out-of-state fabricators with most bridges assembled on site by more or less skilled local construction crews.

Once established, the USRC took immediate steps to standardize culvert and bridge construction. One of their first acts was to establish a recommended formula for concrete mixes used in bridges, along with general engineering guidance for bridge construction. The USRC also specified that bridges constructed with State Road Funds were to be constructed of steel, concrete, or metal. These requirements for state-funded bridges were intended to encourage a trend away from the use of wood and timber in bridge construction and placed a higher priority on permanence rather than expediency and low cost.[117]

One of State Engineer Beers' first goals was to organize an engineering staff to "systematize design and specification according to modern engineering practice."[118] Following on the USRC

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[114] Knowlton, 437.

[115] Alexander, 341.

[116] Eighteenth Biennial Report, 1942-1944, 7.

[117] First Biennial Report, 1909-1910, 17.

[118] Fraser, 20.

initial efforts to establish bridge standards, Beer's instituted the development of standard plans and specifications.

Because of the state's rugged terrain and seasonal desert waterways and sloughs, the majority of crossings could be crossed with small span culverts and bridges. The State Engineer estimated that a majority of crossings ranged between 5 and 45 feet, a span that was most economically addressed using concrete girders and slabs (for a discussion of bridge types and features, see *Glossary of Basic Bridge Types and Terms* at the end of this volume), and by 1913 the engineering staff had produced "Standard Culvert Plans," which contained 50 different culvert designs, including iron, concrete, and stone, recommended for use by the USRC at that time. These were organized into "loose-leaf" notebooks and distributed to Field Agents for purposes of construction and inspection. [119]

Noting that "there are only a very few places in the State where the State Road crosses a stream requiring a span greater than 100 feet" the engineering department placed a priority on standard bridge designs for spans up to and including 100 feet. Because most spans were well below 100 feet, standard designs were developed for steel Warren pony truss, timber Howe truss, and concrete slab and girder bridges. The engineering department also instituted a category of "special designs" where specific situations demanded individual design and engineering or a structure greater than 100 feet was needed.[120]

For the first six steel truss bridges it constructed, USRC used "industry standard" Warren pony spans with riveted connections.[121] Historian Clayton Fraser notes this design closely resembled Salt Lake County bridges constructed by private contractor James Burke and suggests that USRC engineers may have used Burke's shop drawings as a basis for USRC's standard design. By 1916 the USRC redesigned the standard Warren truss and constructed five bridges using the plan.[122] The Price River Bridge at Helper in Carbon County (nonextant), Price River Bridge at Mound in Emery County (nonextant), and the Adamsonville Bridge in Beaver County are examples of trusses that employed early standard plans for truss bridges. Only the Adamsonville Bridge (001003C in Beaver County) is extant.[123] Steel truss bridges constitute less than 0.5 percent of the extant Utah historic bridge population. The oldest extant bridge is a steel truss constructed in 1914 in Carbon County (007027C), and the remaining extant steel truss bridges, except one, were built prior to 1920.

[119] Third Biennial Report of the State Road Commission,1913-1914, 29

[120] Third Biennial Report of the State Road Commission, 1913-1914, 32.

[121] Fraser, 22.

[122] Fraser, 22.

[123] Fraser, 22.

Bridge 001003C, Beaver County, south of Adamsville carrying county road over the Beaver River – an example of a Warren pony truss

Bridge 007027C, Carbon County, 1 mile northwest of Castle Gate carrying county road over the Price River – an example of a Warren pony truss

In the 1915-1916 biennium the USRC reported that standardized bridge and culvert plans were being widely employed for bridge superstructures and sufficed for culverts in almost all cases.[124] The commission concluded that standard plans had saved the state time and hundreds of dollars in design cost since the standard plans enabled bridge construction to proceed quickly following approval and funding. The commission also reported that counties and cities were availing themselves of the plans for their own work off the state and U.S. Highway system.[125]

In the 1919-1920 biennium USRC engineers began experimenting with concrete arch construction. Early examples included Logan (Cache County, nonextant) and Spanish Fork River Bridge (Utah County, nonextant). These bridges were also noted by the USRC as examples of attempts to provide greater design emphasis on structures that fit aesthetically with their urban context.[126] Only two examples of concrete arch bridges remain in the state from the prewar period: one in Cache County (005004D) and one in Utah County (4D 149). One example of a concrete continuous arch bridge remains extant in Washington County (053026D).

Bridge 005004D, Cache County, in the city of Wellsville city street over the Little Bear River – an example of a concrete deck arch

[124] Third Biennial Report, 1915-1916, 30. These standard plan were organized into "loose-leaf" binders. To date no copies of these have been found in the course of research.

[125] Third Biennial Report, 1915-1916, *30.*

[126] Fraser, 42.

Bridge 053026D, Washington County, west of the Ash Creek Reservoir carrying a county road over Ash Creek – an example of a concrete continuous deck arch

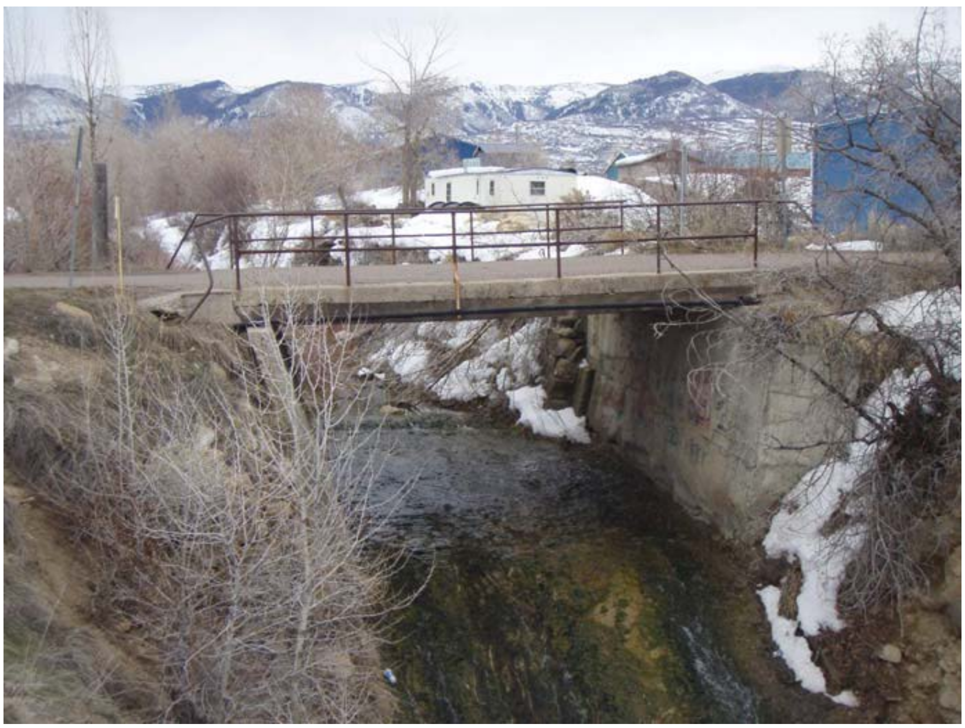
A review of state funded bridge projects listed in the USRC biennial reports during the prewar period indicates that culverts were the most frequently constructed crossing type.[127] These were usually of timber, stone, corrugated iron, or concrete pipe construction. There are no extant culverts from the period 1910-1920 and no examples of timber, stone, or corrugated iron. The existing prewar culvert population consists primarily of examples built in the 1930s and 1940s, and are either concrete or concrete continuous culverts.

Among bridges, timber stringers and pony trusses continued to be widely used. Despite the stated preference of the USRC for concrete and steel bridge materials and the production of standard bridge plans for such structures, many bridges and culverts in the state continued to be constructed of timber. Standard plans for combination wooden/iron truss bridges were developed and appear to have served as a basis for the construction of thirteen "log" or timber truss bridges constructed in 1913-1914 (there are no known extant timber truss bridges).[128] It was calculated that the maintenance costs of timber bridges in alkaline environments was much lower than for steel or concrete materials, so that some of the use of timber and wood materials reflected a

[127] State Road Commission, Biennial Reports of the State Road Commission, 1911-1929. Each Biennial Report contains a county-by-county summary of road and bridge accomplishments accompanied by a summary table that lists all structures, their location, and bridge design type.

[128] State Road Commission, Biennial Reports of the State Road Commission, 1911-1929.

conscious engineering choice.[129] For practical reasons, timber bridges continued to be a popular material for bridge and culvert construction in remote agricultural, desert, and mountain counties where the transport of steel materials and skilled labor was prohibitively expensive. This was particularly true in the northeastern corner of the state in Uintah County where poor roads and no railroad connections left county officials dependent on local materials.[130] Prewar examples include three 1945 timber stringer bridges (039020A, 017011A, 031009A). The majority of timber bridges were constructed in remote and arid counties, because it was practical in arid, alkaline portions of the state.



Bridge 039020A, Sanpete County, carrying 900 East Street over Pleasant Creek in Mt. Pleasant – an example of a timber stringer/multi-beam or girder

The commission also reported in 1918 that changes in the BPR loading standards for bridges made many of its previous plans obsolete, requiring a great deal of work to bring the department's standard plans into conformity with national guidelines. This need for revision slowed new bridge design until new standard designs were completed in 1923 for steel and timber stringers, steel and timber trusses, concrete T-beams and slabs, and steel plate girders.[131] In the 1923-1924 biennium the bridge department announced that structural steel specifications

[129] Fraser, 25.

[130] Fifth Biennial Report, 1917-1918, 71

[131] Fraser, 47.

had been revised to modern standards. Although the particular standard is not referenced, it is likely USRC engineers were following AASHO or BPR guidance.[132]

Although standard plans served a large portion of the USRC's design needs, large crossings and site-specific challenges required "special design" bridges. These included some of the larger bridge projects undertaken. Among bridges that the USRC noted as posing special engineering challenges were the Vega Wash Bridge in San Juan County (1914), a timber truss (nonextant); the Ash Creek Bridge in Washington County (053026D, pictured above) constructed in 1925, the largest concrete arch span built to date; and the Bear Creek Bridge in Box Elder County (1921, nonextant), a concrete T-beam (nonextant).

One of the major influences of the federal assistance programs in the 1930s was a better understanding of the relationship between highway and bridge planning on the part of the USRC bridge department and its engineers. In the Twelfth Biennial Report (1929-1930) the USRC acknowledged that the convenient and economical siting of a bridge was no longer the deciding factor in highway engineering decisions and that "Safety of curvature, good visibility and reasonable grades were now taking precedence over cost," and that state bridge engineers routinely accompanied survey crews to gain a better understanding of conditions and to assist in bridge location selection.[133] The Bridge Department also adopted the loading standards for structures recommended by AASHO during the late 1930s.[134]

A small number of extant concrete T-beam and steel stringer bridges from the 1920s reflect the USRC's issuance of new standard plans for these bridge types in 1923, discussed above. During the 1930s there was a slow but observable increase in the general use of concrete and steel materials and bridge types. By 1937 the bridge department acknowledged a preference for what it termed "modern types of structures," among which it listed rigid frame reinforced concrete, continuous beam, continuous slab, suspended and cantilever beams.[135] It also noted that considerable advancement had been made in in the finished appearance of concrete structures with modest aesthetic treatments to harmonize bridges with their environment.[136]

Review of the biennium reports for the 1930s shows that state bridge design continued to rely heavily on the use of standard plans and specifications for spans 100 feet or less and developed "special designs" for longer spans. Among the special designs were the steel arch Virgin River Bridge in Washington County (0C 158) between Hurricane and La Verkin that spans a 164-foot-deep canyon constructed in 1937, which is listed in the National Register.

[132] Eighth Biennial Report, 1923-1924, 71

[133] Twelfth Biennial Report, 1929-1930, 91.

[134] Twelfth Biennial Report, 1929-1930, 99.

[135] Fifteenth Biennial Report, 1937-1938, 35.

[136] Fifteenth Biennial Report, 1937-1938, 35.

Bridges were a critical part of the World War II program for federal defense highways designed as part of the Strategic Highway Network. Of the 175 bridges located on the strategic network of highways in Utah deemed essential to the war effort, 58 located in Utah were deemed inadequate to carry military loads and 12 were identified as too narrow. In addition to replacing or improving these bridges, the USRC bridge design section designed and constructed new strategic bridges, some of which implemented new technologies such as large-scale welding on highway bridges.[137] Bridges built during World War II constitute a large proportion of extant bridges from the 1940s. The majority of these bridges, like those built in the 1930s, were steel beam and girder and concrete T-beam, along with a number of short span concrete slabs and culverts.

As a result of federal incentives and restrictions that focused activities on the highways and bridges within the Strategic Highway Network leading up to and during the war, Utah emerged from World War II with a backlog of needed improvements on many of the state's other bridges on its 495 miles of state roads at the beginning of the postwar period. At the conclusion of the war, Utah sought to implement a postwar program that took up the slack created by the war and restored war-damaged roads to their required level of service.[138]

(5) City and county roads

From 1909-1931 the USRC had jurisdiction over state roads and U.S. Highways, while county road commissions continued to assume responsibility for county roads and bridges. County roads were defined as roads that did not cross-country lines or intersect with state roads or U.S. Highways. Funding for county projects came from two primary sources: county bond acts (primarily in the 1910s and 1920s) and property taxes. Under this system small, less populated counties were at a disadvantage since their property tax base was low. Many county bridges were constructed with local materials and local labor, although the USRC engineering staff noted that during the 1920s there was an increased use of the state's standardized plans by counties.

In 1931 state legislation that increased the state road mileage through incorporation of some county routes into the state road system discussed above, also made changes in the funding relationship between the state and counties. Under the 1931 legislation the USRC was given financial responsibility for projects on primary roads, which included the over 600 miles of county roads that were transferred to the state under the bill. Counties remained responsible for the reduced mileage of secondary roads. This change in designation also relieved counties of sharing their property tax revenues with the State Road Fund. During the Great Depression, when counties were experiencing severe declines in local funds, the shift of many major county roads to state jurisdiction and the relinquishment of state claims on a portion of local property taxes relieved counties of a significant burden in regard to road and bridge construction.[139]

[137] Fraser, 56.

[138] Eighteenth Biennial Report, 1943-1944, 9; Nineteenth Biennial Report, 1945-1946, 14; Fraser, 55.

[139] Knowlton, 291.

The Federal-Aid National Highway Act of 1944 made federal monies specifically available for "rural" and "urban" road projects. This gave the USRC new authority over county and municipal projects using federal financing. This shifted the decision-making balance in favor of the state, whose approval became necessary for plans and construction in counties.[140]

(6) Achievement of long-term transportation planning goals

Throughout the prewar period the USRC pursued several long term goals intended to create a coherent transportation system that provided good service to automobile travelers and to trucks and agricultural equipment. Although the organization and composition of the USRC changed over time and major events such as the Great Depression and World Wars I and II intervened, the programs retained a high level of consistency and by the end of World War II the USRCs goals had largely been achieved. The following is a summary of major efforts that were undertaken. Some involved more bridge and culvert work than others but overall they were important parts of an improved road and bridge system throughout the state.

(a) Grade separations at railroad intersections

Grade separations of highways at railroad crossings were among the USRC's most active programs throughout the prewar period. In 1918 the USRC initiated a statewide program of grade separations at railroad intersections. Although modest in its beginnings (only three projects were carried out that year), the USRC placed a high importance on this program to improve safety. The program continued through the 1920s and accelerated after the onset of the Great Depression with the increased funding and labor provided by federal public works programs. By 1928 a total of 17 grade crossings had been completed. Among the most important of these 1920s grade separations was the crossing over the main track lines of Union Pacific Rail yard east of Ogden (nonextant).[141] An accident involving a school bus from South Jordan and a train occurred on December 1, 1938, in Sandy and resulted in the death of 23 children. The accident led to federal law requiring school buses to stop and open the doors before crossing railroad tracks.[142] The intersection of the railroad crossing that then existed at 300 West and slightly north of 10600 South continued to be a dangerous crossing until it was closed.[143]

During the period from 1934-1936 the WPA directed $1.25 million in funding for grade-crossing improvements. The USRC responded, only three months after the funding was authorized, by continuing its ambitious program of grade-crossing development. In this biennium the USRC designed 53 major grade-crossing bridges and eliminated others by relocating portions of

[140] Knowlton, 345-352.

[141] Tenth Biennial Report, 1927-1928, 33.

[142] Lee Benson, "Bus crash in 1938 led to train laws," *Deseret News* (Salt Lake City), 21 October 2009, http://www.deseretnews.com/article/705338209/Bus-crash-in-1938-led-to-train-laws.html?pg=1 (accessed 5 June 2011).

[143] "South Jordan," http://en.wikipedia.org/wiki/South_Jordan,_Utah (accessed 5 June 2011).

highway to avoid railroad crossings.[144] In the latter part of the 1930s, the grade-separation program slowed, but remained an important USRC priority. The engineering staff found that several of these grade separations posed significant engineering problems, particularly those involving the Denver Rio Grande Railroad in Salt Lake City.[145]

The USRC grade-separation program continued during the war years with $129,000 expended between 1941 and 1942 and with some notable crossings accomplished on the U.S. Highways.[146] By 1944 the USRC acknowledged that the shortage of steel resulted in the use of concrete for grade-separation bridges during this period.[147]

(b) Road surface improvements

The road system that the USRC inherited in 1909 was generally in poor condition and little more than wagon tracks in many locations. The U.S. Office of Public Roads estimated in 1913 that of 8,300 miles of public road in Utah only 1,000 had been improved to any degree.[148] Four years later, of the 3,440 miles of designated state routes under the jurisdiction of the USRC only 404 miles were graded and the entire state had only thirty-five miles of paved roadway.[149] Despite the limitations of the USRC and lack of professional engineering staff prior to1920, improvements in Utah's road system were accomplished. The primary emphasis in this period in road improvements was increasing the mileage of paved roads within the state. Most of the work was accomplished in the "heavy-usage" areas in Box Elder, Weber, Davis, Salt Lake and Utah counties.[150]

The first federal-aid projects in the state were commenced in 1917 and assisted in paving efforts sufficiently that the USRC could report by 1918 "quite a showing had been made in hard surface pavement."[151] Despite this progress the cost of paving tended to reduce the volume of other road improvements that could be accomplished due to USRC's limited financial resources. In 1925 the USRC decided to defer further large scale paving efforts in favor of grading, graveling, and oiling road surfaces in an all-out effort to get the state's roads "out of the mud."[152]

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[144] Knowlton, 328.

[145] Fifteenth Biennial Report, 1937-1938, 38.

[146] Seventeenth Biennial Report, 1940-1942, 46.

[147] Eighteenth Biennial Report, 1942-1944, 55

[148] Knowlton, 356

[149] Fraser, 36.

[150] Knowlton, 201.

[151] Fifth Biennial Report, 1917-1918, 12.

[152] Ninth Biennial Report, 1925-1926, 1; Tenth Biennial Report, 1927-1928, 8.

Federal relief funding nearly doubled the amount of highway funds available to the USRC. In 1930 the USRC reported that it had more than $4 million at its disposal for road and bridge improvement in the coming year.[153] In 1932 amendments to the Federal-Aid Highway Act removed restrictions on the use of federal-aid highway monies in urban areas for road and bridge construction. These events greatly increased the ability of USRC to pursue its goal of improving road surfacing throughout the state, and during the 1930s USRC undertook a program of widening roads in urban areas to provide for multiple lane roads and divided traffic conforming to the BPR specifications.[154]

The most significant accomplishment in road surface improvements during the period was a shift from gravel as the predominant surfacing material to an oil aggregate mix surface treatment that they viewed as intermediate between gravel/dirt road surface and paving. The oil mixture substantially cut down on dust that was a major road problem in desert areas. By 1931, 560 miles of road were improved, with another 280 miles programmed for the next year's construction program. Projections in the 1937-1938 Biennial Report stated that by 1939 the USRC expected that all of U.S. 40 from the Heber City (southeast of Salt Lake City) to the Colorado state border and U.S. 89 from the former town of Thistle, in Utah County, to the Arizona state border would be completed as a dustless surface.[155] These efforts appear to have little effect on bridge construction. Other road improvements during the late 1930s included a landscaping program intended to beautify roadways and prevent erosion, and a survey of potential roadside parks or rest area sites, which may have resulted in the construction of bridges and culverts.[156]

(c) Road connections to bordering states

Perhaps the biggest limitation of the state's highway system in the early prewar period was the lack of connections to adjacent states. The USRC map of 1910 indicates that with the exception of the northern connection to Idaho, where a number of Mormon settlements existed, the Utah road system was entirely insular, extending in west, east, and south from Salt Lake City only to the last large town or settlement within the state boundaries.

Early in its tenure the USRC articulated the desire to link the state's highway system to that of Colorado, Arizona, and Nevada. Initially progress was slow, but by 1917 the USRC reported that major progress had been made in this area. The biggest efforts were expended on the state road system and on routes that became part of the U.S. Highway system in 1926.

[153] Twelfth Biennial Report, 1929-1930, 26.

[154] Fifteenth Biennial Report, 193701938, 19.

[155] Fifteenth Biennial Report, 1937-1938, 10.

[156] Fifteenth Biennial Report, 1937-1938, 48.

(i) Connecting the Uinta Basin (U.S. 40 in eastern Utah)

The Uinta Basin in the northeastern portion of the state remained a highly isolated and under-populated area well into the 1920s with roads in poor condition and no connection between the eastern-most town of Vernal and the Colorado border. The lack of a railroad or highway connection and the poor condition of the roads made the transport of road and bridge materials to the area difficult and expensive. With the passage of the Federal-Aid Highway Act of 1916, the USRC lobbied to place a portion of road from Duchesne through Vernal to the Colorado state line in the Federal Aid System to secure funding for highway improvements. By 1925 substantial improvements had been made including a 120-foot steel span over the Uintah River (nonextant) and four other bridges between Duchesne and Vernal (the status of these bridge is unknown).[157] This route eventually became part of U.S. 40 connecting Salt Lake City to the Colorado state border.

(ii) Wendover Route to the Nevada state border (U.S. 40)

One of the most important road construction efforts between 1909 and 1929 was the development of a highway between Salt Lake City and the Nevada state border. Both the USRC and the Lincoln Highway Association developed routes around the salt flats west of Salt Lake City to achieve this link. By 1918 the “Seiberling Section” favored by the Lincoln Highway Association was nearing completion.[158] In 1923 construction also was begun on the route favored by the USRC that extended directly west from Salt Lake City to Wendover. This extension of the state highway system was made possible by legislative appropriation and by the contributions of civic organizations in northern California that saw the advantage of a direct route between Salt Lake City and San Francisco.[159] This route was one of the major projects funded under the provisions of the Federal-Aid Highway Act of 1916 and 1921.

The construction of the state road included a number of unusual engineering challenges including building on an encrustation of salt approximately six miles wide and up to four feet deep.[160] Additionally, the rough terrain along much of the route required hundreds of culverts. The highway was completed and opened to traffic in June1925.[161] This road eventually became U.S. 40 connecting Salt Lake City to the Nevada state border.

Among the essential projects during the shift from civilian to military priorities leading up to and during World War II, none was more extensive than improving U.S. 40 on the Wendover route to the Nevada state border. The Wendover route, first completed in 1925, was rebuilt to match Strategic Highway Network standards. This work included two overhead grade crossings (the

[157] Ninth Biennial Report, 1925-1926, 9.

[158] Fifth Biennial Report, 1917-1918, 20.

[159] Fifth Biennial Report, 1917-1918. 23.

[160] Fifth Biennial Report,1917-1918, 47

[161] Ninth Biennial Report, 1925-1926. 19.

status of these structures is unknown), one at Nye's Corner and the other at Hot Springs (nonextant).[162]

(iii) St. George to the Arizona state border (U.S. 91)

Connections in the southern portion of the state were substantially improved in 1925-1926 biennium with grading, widening, and surfacing through Iron and Washington counties in conjunction with improvements to provide highway access to Zion National Park and Arizona. These improvements included the construction of a concrete bridge and a 230-foot tunnel through Middleton Ridge.[163] Portions of this road eventually became U.S. 91 connecting Salt Lake City to Zion National Park and the Arizona state border. Two tunnels in the inventory carrying S.R.12 were constructed in 1941 in Garfield County.

(d) Access to scenic areas of southern Utah

The USRC recognized road improvements were needed to provide access to the scenic red rock and canyon areas to attract tourists to southern portions of the state. This was a goal shared by the federal government, which had recently designated a number of areas in southern Utah as National Parks. Road development in this area was supported by federal-aid projects and through cooperative agreements with the National Park Service. Beginning in the 1917-1918 biennium roads to Zion, Cedar Breaks, and Bryce Canyon National Parks were under construction with an expected completion date of 1925.[164] The dedication of Zion National Park in 1920 and a visit by President Warren G. Harding in1923 also helped draw attention to the area and the need for road improvement. In 1925 the construction of Zion Park-Mt. Carmel Highway was begun as a joint project of the USRC and the National Park Service to create an important connection in the highway system.[165] In 1926 the Arrowhead Trail, the major through access route to the southern Utah area, was made a part of the U.S Highway system with the designation of U.S. 91.

USRC efforts to cooperate with the National Park Service that began in the 1920s continued throughout the 1930s. In fact road construction was central to National Park Service development policy during the Great Depression years. The expenditure for this purpose began in 1931 with a $13 million appropriation and $22 million between 1933 and 1940 for road improvement projects.[166] Joint projects between the National Park Service and the state included major road improvement projects along U.S. 89 to connect Cedar City to Zion National Park.

[162] Knowlton, 415.

[163] Ninth Biennial Report, 1925-1926, 20.

[164] Fifth Biennial Report, 1917-1918, 25.

[165] Ninth Biennial Report.1925-1926, 21.

[166] Flink, 171-182.

As Utah entered the war, the transportation system had been transformed by the establishment of USRC and the development of professional engineering staff that allowed for systematic improvements that were consistently pursued throughout the first half of the twentieth century. Utah did not appear in the forefront of highway and bridge engineering development in this period, but the state made steady progress in developing an integrated transportation network and providing standardized bridge plans for short spans to save time and money. Research suggests that most of the state's bridge crossings were being met with relatively short standardized spans and the "special design" projects focused on a limited number of large crossings. The result may have been less of a need for innovation and a greater focus placed on proven construction practices and practicality.

4. Utah Highway and Bridge Development, 1946-1965

As a result of federal incentives and restrictions leading up to and during the war, Utah went into the postwar period with a "…backlog of surveys, plans and estimates for postwar construction projects." There was a broad state consensus as the war came to an end that Utah had a "great need for improved roads in all its counties," and that many of the state's bridges were in disrepair at the beginning of the postwar period. Due to material, labor, and financial shortages during the war, Utah focused on a program of postwar road and bridge planning by proceeding with surveys and plans for the reconstruction and modernization of 495 miles of state roads.[167]

Between 1946 and 1965, road and bridge-building efforts transformed Utah's (and the nation's) roads into a sophisticated modern transportation network, the result of both state and federal policy and funding initiatives. At the national level, the passage of a number of Federal-Aid Highway Acts in the 1940s and 1950s dramatically increased federal funding for roads. In particular, the Federal-Aid Highway Act of 1956 provided the first real funding for construction of the long discussed Interstate system, and exerted a considerable influence on road and bridge-building during the period. Federal legislation also required national organizations, such as the BPR (later the FHWA) and AASHO (later AASHTO), to work together to develop design standards that would ensure uniformity of highways across the country.

The following sections present historical background on transportation networks in Utah after World War II. Historical themes considered include federal and state legislation and funding that stimulated road and bridge-building efforts; national standards for road and bridge design; and Utah's road and bridge planning and implementation efforts along expressways, Interstate highways, and state primary routes.

A. Federal-Aid National Highway Acts

The Federal-Aid National Highway Act of 1944, discussed in Section 3, set the stage for a number of subsequent funding bills that increased funding for primary roads and for the construction of expressways.

Several federal-aid highway acts were passed in 1946, 1950, 1952, and 1954. However, they were overshadowed by the Federal-Aid Highway Act of 1956 (1956 Act). The acts of the early 1950s continued federal funding to states for road and bridge projects with only slight increases in appropriations and limited funding for the Interstate system. Although the Federal-Aid Highway Act of 1952 authorized the first funding for the Interstate, it was limited to $25 million a year nationally for fiscal years 1954 and 1955. The Federal-Aid Highway Act of 1954 authorized an additional $175 million for fiscal years 1956 and 1957; however, this did not provide enough to begin large-scale construction of the Interstate system. In addition to continuing postwar construction efforts, these acts also provided funds for Interstate Highway planning, which had been previously authorized in the 1944 Act.[168]

[167] Eighteenth Biennial Report, 1943-1944, 9; Nineteenth Biennial Report, 1945-1946, 14; Fraser, *Historic Overview*, 55.

[168] Federal Highway Administration, "The Dwight D. Eisenhower National System of Interstate and Defense Highways," Federal Highway Administration, http://www.fhwa.dot.gov/reports/routefinder (accessed 15 December 2009).

The 1956 Act not only substantially increased federal appropriations to states for primary, secondary, and urban highway construction, but also made the first significant appropriations for construction of the Interstate system. The 1956 Act authorized the expenditure of $25 billion dollars over a 12-year period for construction of a "National System of Interstate and Defense Highways." The system would include 41,000 miles of new roads, built to "the highest standards" of safety and efficiency, and would be funded by increases in federal gas, tire, and vehicle taxes. Revenues would be collected in a newly created Highway Trust Fund that would enable the federal government to complete the system on a "pay-as-you-go" basis. Each state would be responsible for completing sections of the system within its borders, with 90 percent of the funding provided by the federal government. The 1956 Act also authorized an initial 13-year construction period for Interstate highways, which would eventually be extended as states faced routing and funding difficulties. Lawmakers passed the bill with only one dissenting vote and pledged that the entire network would be completed by 1972.[169]

Interstate highways built in Utah as a result of the 1956 Act are discussed in Section 4.B(3)(c). Utah's initial apportionment of federal monies from the 1956 Act included $10,935,309 for fiscal year 1957 and $24,668,403 for fiscal year 1958.[170]

B. State funding, policies, and construction programs

(1) Utah highway legislation and funding

Utah highway legislation between 1945 and 1965 dealt primarily with three issues: 1) introduction of limited-access roadways and the implications of the design requirements on routing and right-of-way; 2) state funding for highways and roads; and 3) administrative reorganization. This latter issue is discussed in Section 4.B(2).

(a) Limited access roads and right-of-way

Much of Utah's highway program was carried out under the federal authorization and implementation legislation in the Federal-Aid Highway Acts of 1944 and 1956. The design of the new limited-access highways to federal standards created a significant need to acquire property to expand existing right-of-way and create new right-of-way along proposed routes. Between 1944 and 1946, the USRC recommended legislation that would allow the agency to acquire property to meet immediate needs and hold land for future needs to control costs. As a result, the state legislature enacted the limited-access law in 1945, which was the principal state legislation pursuant to the federal program that allowed for postwar highway improvements. This Utah law followed the form for such state legislation that was recommended by the U.S. Public Roads Administration.[171] The law authorized the USRC, counties, cities, and towns to design

[169] Johnson, 181; Tom Lewis, *Divided Highways: Building the Interstate Highways, Transforming American Life*, (New York, NY: Viking, 1997), 121; Richard F. Weingroff, "Federal-Aid Highway Act of 1956: Creating the Interstate System," Federal Highway Administration, http://www.fhwa.dot.gov/infrastructure/rw96e.htm (accessed 12 December 2009).

[170] Twenty-Fourth Biennial Report, 1955-1956, 9.

[171] Nineteenth Biennial Report, 1945-1946, 17.

limited-access facilities and regulate, restrict, or prohibit access from adjoining property or intersecting roads.[172] Right-of-way proved to be an expensive and contentious issue, especially within heavily populated urban corridors. Lawsuits and funding from the Federal-Aid Interstate highway program led the USRC in 1956 to recommend the creation of a full-time legal department to deal primarily with right-of-way issues.[173] By March 1958 a legal department was in place within the USRC. It included staff to address right-of-way claims, agreements, legal advice, and contracting procedures.[174] In 1959 the USRC recommended the creation of a revolving fund to aid in the purchase of right-of-way, which had increased tenfold since 1952. The legislature acted favorably on this request and established a $5 million fund.[175]

(b) Funding state highways and developing revenue

The principal sources of state highway funding continued to be derived from the state gas tax, and, to a lesser degree, motor vehicle registration fees. In 1951 the Utah legislature acted to increase the tax from four to five cents per gallon, which assisted in meeting rising costs associated with materials and labor following the war. This action significantly increased the amount of state funds available, with the gasoline tax accounting for 56 percent of the $40 million operating fund.[176]

The 1956 Act shifted the balance between state and federal funding. While the gas tax remained an important component of the agency budget, by 1959 the federal contribution had risen to 50 percent of annual funding. The gas tax constituted 37 percent of revenues with the remaining 13 percent coming from other state sources. While state and federal revenues were evenly matched, federal funds played a disproportionate role in funding road and bridge construction, accounting for 80 percent of funds expended.[177] The reduction of federal-aid funding that followed the 1959 Act resulted in the USRC taking action to “stretch” federal dollars, prioritizing projects based on traffic volumes and building some Interstate highways to the minimum AASHO standards with the expectation to upgrade the highways in the future.[178]

(2) The Utah State Road Commission

The effects of the reorganization of Utah state government, including the USRC, that had commenced with the election of Herbert Maw as governor in 1941 (as discussed in Section 3) continued into the postwar period. During most of the 1950s Governor Maw exercised powers

[172] Nineteenth Biennial Report, 1945-1946, 85.

[173] Twenty-Fourth Biennial Report, 1955-1956, 7, 21.

[174] “Organization Gets Overhaul,” *Utah Highways and Byways* 2, no. 2 (November 1958): 3.

[175] “Right of Way Revolving Fund Asked by Commission,” *Utah Highway Progress* 2, no. 13 (January 1959): 1.

[176] Twenty-Second Biennial Report*, 1951-1952*, 7.

[177] “State Highway Financing,” *Utah Highways and Byways* 2, no. 12 (September, 1959): 2. In 1958 gas taxes accounted for 60 percent of highway revenue and Federal-aid accounted for 32 percent of funding.

[178] “Commission Inaugurates Dollar Stretching Plan,” *Utah Highways and Byways* 3, no. 2 (November 1959): 4.

that had previously resided with the USRC, including approval of Federal-Aid projects and oversight of the expenditure of Federal-Aid funds. Maw also executed road project agreements with local governments. These "reforms" continued until 1957, when newly elected Governor George Clyde abolished the Engineering Commission, expanded the membership of the USRC, and returned the powers the USRC had lost under Maw.[179]

Legislation in 1957 reorganized the USRC by increasing its membership from three to five bi-partisan gubernatorial appointees. The reorganization bill sponsored by Governor Clyde revoked the authority of the Engineering Commission created by the previous administrations and restored the autonomy of the USRC, re-establishing many of its pre-1941 powers. The shift to an autonomous USRC was intended to produce efficiencies in project programming. It appeared to have achieved this goal with a 125 percent increase in the number of projects let for construction in its first year of operation.[180]

In turn, the newly reorganized USRC initiated major highway department reorganization, adding two new assistant directors, including one specifically for engineering. The reorganization was intended to modernize and rationalize the almost 50-year-old department, establishing clear reporting relationships and responsibilities.[181] Reorganization efforts continued into the early 1960s with the addition of new technologies such as photogrammetry and computers.[182] In 1960 the highway department's role was clearly defined in legislation as the administrative arm of the USRC. As part of the larger reorganization in the late 1950s, the bridge design section was renamed the Structure Division, and it reported directly to the Chief Engineer.[183] Symbolic of the USRC's enlarged programs, in the spring of 1959 the state broke ground for a new office building in Salt Lake City to meet the needs of the expanding department. The new headquarters opened in 1960.[184]

In a more public relations-oriented postwar world, the USRC began issuing an "in-house" publication entitled *Utah Highways and Byways*, which presented information on current projects and matters of department interest. The new publication was less technical in content than the department's biennial reports and served as a vehicle to highlight major projects throughout the state. At the same time, the USRC also began issuing an information sheet entitled *Utah*

[179] Seventeenth Biennial Report, 1940-1942, 378-383, 569. The state road legislation was contained in Chapter 9, *First Special Session Laws of Utah*, 1941.

[180] Knowlton, 569; "Five-Man Commission Observes First Birthday," *Utah Highways and Byways* 1, no. 7 (April 1958): 1.

[181] "Organization Gets Overhaul," 2.

[182] "IBM Installation Cuts Engineering Time," *Utah Highways and Byways* 2, no. 4 (February 195[9]): 4.

[183] *State of Utah, Compiled Digest of Administrative Reports for Fiscal Year Ended June 30, 1960 to the Legislature, the Governor and for Other Essential Purposes* (Salt Lake City: State of Utah, 1960), 106; "New Structure Division Formed," *Utah Highways and Byways* 1, no. 12 (September 1958): 1.

[184] "New Home for Department of Highways," *Utah Highways and Byways* 3, no. 7 (April 1960) 1.

Progress, which covered "highlights of the activities of the State Road Commission" for a more general audience. It is not entirely coincidental that these more publically accessible accounts of USRC activities corresponded with the initiation of the Interstate highway program in the state. The first issue of *Utah Highways and Byways* introduced the system in the article "Utah to Be Link in New Interstate Highway System," along with a glossary of "new highway construction terminology" and illustrations of the then revolutionary interchange design for limited-access roads.[185]

In 1975 the USRC was dissolved and its duties were transferred to the new Department of Transportation.[186]

(3) State highway programs and implementation efforts

As the reorganized USRC emerged from the war years, it identified highway and secondary road repair as a critical state need, estimating that at current expenditure levels it would take 20 years to "barely…bring the State Road System to necessary standards required for present and anticipated traffic."[187]

The three-year appropriation for states authorized by the 1944 Act provided funding to begin the work of civilian highway and bridge construction. The USRC's Nineteenth Biennial Report (1945-1946) called for the improvement of 227 miles of state highways and secondary roads and repair of some of the most deficient bridges in the state. However, the commencement of this program was slowed by a number of factors including an immediate postwar shortage of critical materials, especially steel, and a lack of qualified engineers to undertake preliminary engineering studies and design.[188]

Although construction materials became more available by 1948, their cost increased substantially as a result of postwar inflation. Cost was a particular concern for bridge work as increased costs of materials and labor limited the numbers of bridges that could be programmed for repair or replacement at any one time. In the face of these constraints, the USRC established a goal to replace a few bridges every year with emphasis on primary Federal-Aid system structures, while also expressing "grave concern" at this situation.[189] In an interim attempt to reduce public safety hazards, the USRC posted many bridges for less than legal loads and district engineers organized bridge maintenance crews to conduct repairs as quickly as possible.[190]

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[185] "New Highway Construction Brings Added Terminology," *Utah Highways and Byways* 1, no. 1 (October 1956): 4.

[186] Laws of Utah, 1975, Chapter 204, pages 915-927.

[187] Nineteenth Biennial Report, 1945-1946, 16.

[188] Nineteenth Biennial Report, 1945-1946, 15, 23.

[189] Twenty-first Biennial Report 1949-1950, 26.

[190] Twenty-first Biennial Report 1949-1950, 32.

The focus on defense related road work during the war resulted in a significant backlog of maintenance and inadequate structures throughout the state. The USRC's Twenty-first Biennial Report (1949-1950) estimated that all of the state's bridges would "require replacement in the very near future."[191] Of the existing 694 bridges with a minimum 20-foot span length in 1949, 451 or 65 percent were deemed inadequate either due to having widths less than established standards, falling under the minimum loading capacity of HS-15, or lacking standard 15-foot clearance.[192]

Between 1947 and 1956, the USRC implemented a goal of slow but steady bridge replacement and improvement, constructing an average of 36 bridges a year between 1947 and 1956. The majority of new bridges along Utah's roadways in this period were reinforced concrete. Progress in bridge building was evidenced in 1948 with the completion of 27 structures with more than a 20-foot span length throughout the state, a significant increase over the six bridges completed in 1944 and 1945.[193] The USRC succeeded in reducing the number of inadequate structures from a high of 65 percent in 1950 to 54 percent by 1956.[194] Other notable bridge improvement projects during the subject period included a number of bridges on U.S. 50 between Green River and Cisco on the eastern boundary of the state. Perhaps the most spectacular project of the early 1950s was the 1,000-foot span across the Colorado River near Moab (currently under replacement) that attracted national attention.[195] Additionally, during the subject period, the USRC took significant steps towards establishing a network of high-standard expressways and Interstate highways, which involved numerous bridge construction projects to separate at-grade traffic, as enabled by the 1956 Act.

During the immediate postwar period, the USRC faced a shortage of qualified engineers. This was a national problem in the immediate postwar period, but it was exacerbated in Utah by one of the lowest wage scales in the country.[196] As mentioned in Section 3, the USRC recommended legislation in 1941 that would give them independent power to establish compensation schedules in order to attract engineering professionals to the department. Although they were finally given

[191] Twenty-first Biennial Report 1949-1950, 26.

[192] Twenty-first Biennial Report 1949-1950, 27. Figures for "inadequate" structures and estimates of improved structures vary from one Biennial Report to another. In this document the figures cited are drawn directly from the USRC reports. However, without knowing what standard the USCR used in determining "inadequacy" it is difficult to estimate the exact number of problem structures and the rate at which bridges were brought up to contemporary standards. The figures cited do indicate that the USRC was acutely aware that a large number of bridge problems existed across the state and was attempting to address the problem on an incremental basis. Vehicles that may use a bridge with AASHTO loading of H-15 (15 tons) or HS-15 (27tons) include typical farm vehicle (15 tons), school bus carrying up to 84 passengers (15 tons), loaded garbage truck (27 tons), and single-unit fire engine (27 tons).

[193] Nineteenth Biennial Report, 1945-1946, Table 5A, 129; Twentieth Biennial Report, 1947-1948, Table 5A, 123.

[194] Twenty-fourth Biennial Report, 1955-56, 23.

[195] Twenty-third Biennial Report, 1953-1954, 28.

[196] Twentieth Biennial Report, 1947-1948, 11; 21; Nineteenth Biennial Report, 1945-1946, 11.

this authority by the 1947 legislature, it did little to immediately remedy the Highway Department's workforce shortage.[197] In 1948 the USRC reported that a survey conducted in the engineering departments of Utah's universities revealed that not a single graduate was interested in a highway engineering career in the state.[198] Engineers who did go to work for the USRC had a low retention rate, moving on quickly to better paying departments in other states.[199] By 1958 the highway department established a personnel program to deal with salaries, promotions, and other personnel actions.[200]

(a) The role of consultants and contractors in Utah's road and bridge-building efforts

As discussed in Section 3, the use of contractors in the prewar period for construction appears to have increased through the 1930s and 1940s after federal-aid appropriations restricted the use of convict labor, but design and field inspection were within the purview of the USRC. As the volume of road construction increased in the 1950s, particularly after the passage of the 1956 Act, contract construction work increased as well. A significant number of construction companies were hired between 1946 and 1965 to meet the demand for highway and bridge work. Prominent among contractors during the study period were W.W. Clyde, brother of Governor George Clyde, and the Morrisson and Knudsen Company.[201]

The Interstate program and the large increases in Federal-Aid Highway funding following the 1956 Act presented the USRC with a dilemma as to how to accomplish the projected engineering workloads that would result from more funding and accelerated Interstate construction. The USRC, like many state highway departments, had been plagued since the end of World War II by a shortage of qualified engineers, caused at least in part by a low salary scale and the lack of a civil service system that guaranteed merit promotion and job security.[202]

Like many other highway departments throughout the country, the USRC made a decision to engage the services of private engineering firms to meet the need for qualified engineers to undertake preliminary studies, site survey, and design. Utah's decision was part of a larger national trend to employ private firms in the area of road and bridge design. In 1954 the University of California, Berkeley, Institute of Transportation and Traffic Engineering reported that 37 highway departments throughout the country had engaged contract engineering services from the private sector. The great majority of this work was for design, specifications, and construction cost estimates.[203]

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[197] Knowlton, 441.

[198] Twentieth Biennial Report 1947-1948, 11.

[199] Twenty-first Biennial Report 1949-1950, 10.

[200] "First Phase Personnel Program Underway," *Utah Highways and Byways* 1, no. 6 (March 1958): 4.

[201] Knowlton, 714.

[202] Twentieth Biennial Report, 1947-1948, 11, 21; Nineteenth Biennial Report, 1945-1946, 11.

[203] Knowlton, 589.

An early example of the USRC's employment of consultants was the hiring of the firm DeLeuw, Cather & Company in July 1958 to review and revise the 1947 traffic origin and destination study for the Salt Lake City metropolitan area and to develop a detailed design for connecting the traffic arteries and interchange locations on the controversial urban freeway.[204] The employment of DeLeuw, Cather & Company took the form of a policy decision that involved more than just the hiring of an outside firm for a specific study. The USRC minutes recorded that it was the USRC's intent that "in order to get the [Federal-Aid] program moving, any work that can be farmed out properly, should be handled by a qualified consulting engineering firm…"[205] According to the UDOT historian, Ezra Knowlton, this policy led to the hiring of a dozen consulting engineering firms between 1957 and 1961 with approximately $4.5 million expended in consulting fees, the largest expenditure in the western states.[206] Most of Utah's contract engineering and design work was concentrated on Interstate-related design in the metropolitan corridor between Ogden and Provo along Interstate 15 (I-15).[207] In 1958 the USRC acknowledged the importance of contract engineering work by establishing a new department position for a supervisor of consulting engineers.[208]

(b) Expressway design and construction

Since the USRC was restricted from construction during World War II, the agency used this time to develop freeway plans beginning in the late 1940s, and after World War II the USRC began designing expressways and freeways, or controlled-access highways, as directed by the 1944 Act. AASHO publications from the mid-1950s define expressways as roadways that "may be entirely at grade with partial control of access and principal cross streets separated," whereas freeways feature "full control of access with all cross streets grade separated or terminated."[209] By definition, the Interstate system is an example of a freeway, whereby "all at-grade intersections of public highways and private driveways shall be eliminated, or the connecting road terminated, rerouted, or intercepted by frontage roads."[210]

Expressways and freeways were designed to provide fast and safe mass transportation within and through metropolitan areas. The objective of the expressway and freeway was to separate through traffic from cross traffic, which included turning vehicles, parked cars, and pedestrians.

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[204] Knowlton, 591. In the 1970s Deleuw, Cather & Company was absorbed by Parsons Engineering.

[205] Knowlton, 592.

[206] Knowlton, 592.

[207] "Consulting Engineer Work Underway," *Utah Highways and Byways* 1, no. 5 (February 1958): 1.

[208] "State appoints New Road Assistant for Contracting Engineering," *Utah Highways and Byways* 1, no. 11 (August 1958): 4.

[209] American Association of State Highway Officials, *A Policy on Arterial Highways in Urban Areas*, 3.

[210] American Association of State Highway Officials, *A Policy on Design Standards: 1-Interstate System, 2-Primary System, 3-Secondary and Feeder Roads* (Washington, D.C.: American Association of State Highway Officials, 1956), 3.

These roads were able to handle three to four times the traffic volume of highways and city streets of the same width. Ingress and egress was available only at designated control points, and bridges or overpasses (grade-separation structures) were required at most intersections to eliminate at-grade crossings and improve safety and traffic flow.[211]

Interstate construction in the 1950s led to construction of a number of overpasses and interchanges to provide grade separations between the Interstate and secondary roadways. In Utah grade-separation structures were first constructed to separate railroad and highway traffic. With the construction of more complicated roadway networks in the 1950s, they were used to separate automobile traffic on expressways and Interstates. This was particularly necessary in urban areas along expressways and Interstates where congestion due to heavy automobile traffic could not be avoided.

In the 1950s specialized expressway-related grade-separation structures, including overpasses, underpasses, and more complicated multi-level interchanges, became an increasing part of the USRC's bridge-building program. Although expressway design, including associated interchanges and overpasses, was expanded after the 1944 Act established separate funds for urban highways, it was not until AASHO published several design policy books that the accumulated national engineering experience became readily available and codified. The 1954 AASHO *Policy on Geometric Design of Rural Highways*, the 1956 *Geometric Design Standards for the National System of Interstate and Defense Highways*, and the 1957 *Policy on Arterial Highways in Urban Areas* provided guidance on the geometric design of expressways with particular consideration given to traffic operation and driver behavior.[212] Additional discussion of these AASHO documents and publications related to bridge specifications is included in Section 5.A.(1).

During the subject period, established forms of interchanges included the T, Y, cloverleaf (partial or full), trumpet, diamond, directional, and rotary types.[213] In particular, the directional interchange type was utilized for the intersection of two high-volume freeways. This type of interchange, which often includes several structures or multi-level structures, results in free-flow paths with little extra travel distance. During the subject period, urban freeway and interchange

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[211] Laurence I. Hewes and Clarkson H. Oglesby, *Highway Engineering* (New York: John Wiley & Sons, Inc., 1954), 36.

[212] American Association of State Highway Officials, *A Policy on Geometric Design of Rural Highways,* n.p.; American Association of State Highway Officials, *A Policy on Design Standards: 1-Interstate System, 2-Primary System, 3-Secondary and Feeder Roads*, n.p.; American Association of State Highway Officials, *A Policy on Arterial Highways in Urban Areas*, n.p.

[213] American Association of State Highway Officials, *A Policy on Geometric Design of Rural Highways*, n.p.; American Association of State Highway Officials, *A Policy on Design Standards: 1-Interstate System, 2-Primary System, 3-Secondary and Feeder Roads*, n.p.; American Association of State Highway Officials, *A Policy on Arterial Highways in Urban Areas*, n.p.

concepts evolved and responded, in particular, to the factors of high traffic speed and high volume.[214]

Despite its problems, the USRC progressed in improving and modernizing the highway system with expressways in the immediate postwar era. The USRC initiated its first controlled-access highway projects in 1947, with 19 miles of roadway completed by 1948.[215] Of the three initial projects, two were two-lane highways and the other was a four-lane divided highway, all of which included provisions to regulate, restrict, or prohibit access to the facilities. These initial projects were located in the heavily travelled urban corridors of Utah, Salt Lake, Davis, and Box Elder Counties. The USRC's efforts to add expressways to the state's highway system is evidenced by their construction of four additional controlled-access projects in 1948 and simultaneous announcement that they had "several such projects in the planning stage."[216] In its publications and news releases, the USRC extolled the benefits of the new controlled-access expressways, including the Interstate system, as significant improvements in both safety and convenience. With standardized 12-foot traffic lanes and 10-foot shoulders, the divided highway allowed motorists to move safely along at 55 miles per hour.[217]

Of the USRC's planned expressway projects, none was more important or more controversial than the proposed north-south expressway (which would later become I-15) through metropolitan Salt Lake City. An origin and destination traffic study of the Salt Lake metropolitan area was completed in 1947 to assess highway needs and establish a potential route for an urban expressway. The USRC's initial proposed route met substantial opposition from local government, the press, and the public.[218] Running through settled and established areas, the proposed 250-foot-wide right-of-way corridor required the acquisition and removal of a large number of residential and commercial properties. Unable to resolve conflicts between the city and state, the project made little progress until a joint city-state engineering team formed in 1950 to address right-of-way issues. In the same year, a grade-separation overpass (nonextant) to span the railroad near Beck's Hot Springs, north of downtown Salt Lake City, was approved, signaling the first step in the design and construction of the I-15 urban expressway. However, progress along I-15 stalled as a result of continued political infighting.[219]

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[214] Donald W. Loutzenheiser, "New Concepts for Urban Freeway Interchanges," *Journal of the Highway Division: Proceedings of the American Society of Civil Engineers* 88, issue HW1: 31, 36.

[215] Twentieth Biennial Report, 1947-1948, 15. The three projects included F-212 North Farmington Junction in Davis County, F-33 in Box Elder and Cache Counties, and FI-119 in Salt Lake and Utah Counties.

[216] Twentieth Biennial Report, 1947-1948, 17.

[217] "Interstate System in Perspective," *Utah Highways and Byways* 1, no. 8 (May 1958): 1.

[218] Knowlton, 453.

[219] Knowlton, 495.

(c) Interstate development in Utah

The passage of the 1956 Act, which funded the construction of a national system of Interstate and Defense Highways, launched an era of unprecedented road construction in Utah. The funding made available to states raised Utah's highway expenditures from $4.2 million in 1950 to $51 million in 1960. Director of Highways C. Taylor Burton reported in 1963 that the largest part of the increase in highway construction was attributable to the USRC's development of the National Interstate System of Highways. Utah's portion of the Interstate was anticipated to total 935 miles when it was completed in the mid-1970s.[220] This mileage included four major projects:

- I-15 – a north-south route extending from the state's border with Idaho to its border with Arizona
- I-80 – an east-west route running from Nevada through Salt Lake City to the Wyoming border
- I-70 – an east-west route through the central part of the state linking the Colorado border to I-15 in Millard County
- I-84 – a north-south route that runs from Idaho border north of Snowville to a junction with I-80 near Echo

Utah's Interstate mileage also included 29 miles of urban expressway around and through Salt Lake City (I-15 and I-215), which was part of the highly controversial metropolitan expressway corridor first proposed in 1948.[221]

Early in the Interstate design and programming process, the USRC prioritized the building of Interstate system segments by need, regardless of their location in the state. This policy led to a patch work of Interstate projects, such that no single route was developed in continuous phases.[222] By 1963 Interstate projects were spread over 11 of the state's 29 counties. As a policy, the USRC favored Interstate projects that addressed highway segments that were in poor condition. This avoided costly repairs to existing highways that would otherwise be replaced a few years later with new Interstate construction.[223]

Although the USRC applied this policy throughout the state, it consistently found that the area of greatest need was the three-county area of Davis, Salt Lake, and Utah Counties. The primary expenditure of Interstate Federal-Aid funds in the early to mid-1960s was made in these counties,

[220] Vance M. Holland, "Utah's Highway Construction Program Progresses on Schedule," *Utah Highways and Byways* 5, no. 6-9 (June 1962): 5.

[221] "Vance M. Holland, "Utah's Highway Construction Program Progresses on Schedule," 5.

[222] The single exception to this was the I-70 route between Salina and the Colorado River, which was constructed as a continuous corridor in 1968-1969.

[223] Vance M. Holland, "Utah's Highway Construction Program Progresses on Schedule," 5.

which contained the state's largest concentration of population. Issues of traffic congestion in the Salt Lake City metropolitan area was recognized before World War II and verified in the 1947 traffic study.[224] In addition to the need to resolve urban congestion problems, the intersection of the state's major north-south (U.S. 91/I-15) and east-west (U.S. 50/I-80) transportation corridors in Salt Lake City focused the USRC's attention and priorities in this heavily traveled area. While public opposition to routing proposals stalled the first plans for an expressway through the west side of the city, the passage of the 1956 Act pushed the modernization projects forward.

The first Interstate project in Utah was a six-mile segment of an eight-lane, limited-access divided highway (I-15) connecting the long-planned Beck's Springs overpass (nonextant) with North Bountiful, located north of Salt Lake City. Originally proposed as a four-lane expressway in 1948, the project grew to encompass an eight-lane roadway by the time of its construction in 1958 and 1959.[225] As Governor George D. Clyde broke ground for I-15 in a public ceremony in February 1958, another 15 Interstate projects were starting construction.[226] On August 1, 1958, the state dedicated its first component in Utah's Interstate system – the 813-foot Beck's Springs Overpass (nonextant) in North Salt Lake City.[227] By the end of the USRC's 1959 fiscal year, 61 miles of Utah's Interstate system were either completed or under construction, and planning and design activities had begun on an additional 300 miles of Interstate highway.[228]

The Interstate program proceeded rapidly, particularly after the augmentation of funding contained in the 1956 Act. However, in the fall of 1959 concerns over the status of the Highway Trust Fund led to a U.S. Congressional failure to pass a federal-aid highway bill, as anticipated. The federal funding crisis resulted in a temporary halt on work underway and a freeze on contracting. When a bill eventually passed, it reduced funding to approximately 70 percent of previous levels. This reduction led the USRC to adopt a policy of "dollar stretching," whereby subsequent portions of the Interstate would be built to AASHO standards for basic construction, with the intent of bringing the road up to higher-level national standards at a later date. In practice this meant that two-lane highways were initially constructed with right-of-way reserved for the future addition of two more lanes to create a full divided four-lane highway.[229] This policy of reduced construction does not appear to have resulted in penalties in Utah's federal highway funding or sanctions from the BPR.

[224] Knowlton, 453.

[225] State Crews Commence Salt Lake Freeway," *Utah Highways and Byways* 2, no. 4 (February 195[9]): 2.

[226] "Utah to be Link in New Interstate Highway System," *Utah Highways and Byways* 1, no. 1 (Oct 1957): 4; "Unique Ceremony Marks Opening of Freeway," *Utah Highways and Byways* 1, no. 5 (February 1958): 4.

[227] *State of Utah, Compiled Digest of Administrative Reports for Fiscal Year Ended June 30, 1959 to the Legislature, the Governor and for Other Essential Purposes*, (Salt Lake City: State of Utah, 1959), 100; "Bridge Design Division – Century and a Half of Service," *Utah Highways and Byways* 1, no. 8 (May 1958): 2.

[228] *State of Utah, Compiled Digest of Administrative Reports for Fiscal Year Ended June 30, 1959 to the Legislature, the Governor and for Other Essential Purposes*, (Salt Lake City: State of Utah, 1959), 101.

[229] "Commission Inaugurates Dollar Stretching Program," *Utah Highways and Byways* 3, no. 2 (November 1959): 4.

In spite of reduced funding after 1959, the USRC remained committed to completing the Ogden to Provo urban corridor along I-15.[230] In addition to continuation of Interstate work in the three-county urban area, the USRC initiated work along 10 miles of I-84 in the Tremonton area north of Ogden, which became the second completed Interstate project in Utah.[231] This Interstate segment included a total of 11 structures, one of which was a farm equipment overpass.[232] Extant bridges along this segment of I-84 include Bridge 0E 1127 carrying I-84 over Blue Creek, built in 1958; Bridge 0E 1129 carrying I-84 over a farm road underpass, built in 1959; Bridge 2D 618 carrying I-84 at the Pine Creek Interchange, built in 1959; Bridge 2D 619 carrying I-84 over State Primary Route (S.R.) 83, built in 1959; Bridge 4D 618 carrying I-84 at the Blue Creek Interchange, built in 1959; and Bridge 4D 619 carrying I-84 over S.R. 83, built in 1959.

The USRC noted that a total of 44 bridge contracts were let in 1961, the majority of which were located on or over the Interstate, particularly in the urban corridor along I-15 from Ogden to Provo. This trend continued through the study period with the completion of a number of viaduct, bridge, and grade-separation structures.[233] Other important segments of Interstate highway completed in the early to mid-1960s included stretches of I-15 between Fillmore and Cove Fort and between Cedar City and Saint George in the southern portion of the state. Between 1963 and 1967 the metropolitan I-15 corridor from Ogden through Salt Lake City to Provo was largely completed.[234]

In the late 1960s, as construction in the urban Salt Lake City area encompassing Davis, Salt Lake, and Utah Counties was drawing to a conclusion, expansion of the Interstate system in the west, south, and central portions of the state increased. In 1967 the USRC embarked on construction of a large stretch of I-70 from Salina to the Colorado River through remote Sevier and Emory Counties.[235] This portion of the Interstate was part of a 1,000-mile addition to the original 40,000 miles of Interstate Highway authorized by the 1956 Act.[236] I-70 provided a connection between Denver and Salt Lake City, intersecting I-15 at Cove Fort. During 1967, a major section of I-80 from Wendover to Knolls, across the Bonneville Salt Flats, was also completed. A link between this Interstate segment and Salt Lake City (I-15) was completed in

[230] "Commission Inaugurates Dollar Stretching Program," *Highway Progress* 2, no. 12 (25 November 1959):

[231] Knowlton, 901. Utah saw a reduction of approximately $10 million in the years following their Federal-Aid funding high of $36 million in 1959.

[232] "District 6," *Utah Highways and Byways* 1, no. 10 (July 1958): 3.

[233] *Utah Compiled Digest of Administrative Reports for Fiscal Year Ended June 30, 1963 to the Legislature, the Governor and for Other Essential Purposes* (Salt Lake City: [State of Utah], 1963), 95; *State of Utah, Compiled Digest of Administrative Reports for Fiscal Year Ended June 30, 1964 to the Legislature, the Governor and for Other Essential Purposes*, (Salt Lake City: State of Utah, 1964), 99.

[234] Utah Department of Highways, *Utah Federal-aid Interstate System Map, 1966-1967.*

[235] Utah Department of Highways, *Utah Federal-aid Interstate System Map, 1958-1959*.

[236] "Settling the Dust on Highway Financing," *Utah Highway Progress* 2, no. 7 (29 July 1959): 1.

1970. Central and southern portions of I-15 were expanded annually until the last section of Interstate was completed between Levan and the northern boundary of Millard County in 1971.[237]

i. Interstate bridges and grade-separation structures in Utah

While bridges that carry the Interstate system are excluded from National Register evaluation under this study, an analysis of Interstate bridges was conducted for contextual information. Of extant bridges and culverts built in Utah between 1946 and 1965, nearly 28 percent are structures that carry the Interstate. The most prominent bridge types facilitating traffic on the Interstate highway system in Utah are the continuous concrete T-beam and the steel beam and girder, both of which comprise approximately 21 percent of the bridges carrying the Interstate system that were built between 1946 and 1965. The prestressed concrete beam and girder (approximately 18 percent) and reinforced concrete rigid frame (approximately 13 percent) are also well represented on the Interstate system.

Early examples of Interstate-related grade-separation structures include the Lowe Interchange in Tooele County (Bridge 0D 621), a continuous concrete T-beam completed in 1959 to carry a county road over I-80, and the Snowfield Underpass (Bridge 0D 636), a 1959 continuous concrete T-beam carrying a county road over I-15 in Washington County.[238] One of the largest Interstate-related structures of the subject period was identified in the USRC's 1963-1964 annual report as the largest structure of the year, a multi-level interchange that included two bridges and three roadway levels (status is unknown).[239]

Of the 23 overpass structures identified between 1946 and 1965 carrying roadways over the Interstate highway system, the most prominent bridge types included the prestressed concrete beam and girder (approximately 36 percent) and the concrete continuous T-beam (approximately 32 percent). Other types utilized for Interstate overpass structures include the continuous reinforced concrete beam and girder, steel beam and girder, and continuous steel beam and girder. Additional information on these bridge types is provided in Section 4.

(d) United States and State Primary Route Highways

While Interstate highways were a newly conceived road system, the U.S. highway and S.R. highway systems were well established, mature systems at the end of World War II. U.S. and

[237] Utah Department of Highways, *Utah Federal-aid Interstate System Map 1966-1967; Utah Federal-aid Interstate System Map, 1967-1968.*

[237] Utah Department of Highways, *Utah Federal-aid Interstate System Map, 1970-1971.*

[238] *State of Utah, Compiled Digest of Administrative Reports for Fiscal Year Ended June 30, 1959 to the Legislature, the Governor and for Other Essential Purposes*, (Salt Lake City: State of Utah, 1959), 100; *State of Utah, Compiled Digest of Administrative Reports for Fiscal Year Ended June 30, 1960 to the Legislature, the Governor and for Other Essential Purposes* (Salt Lake City: State of Utah, 1960), 108.

[239] *State of Utah, Compiled Digest of Administrative Reports for Fiscal Year Ended June 30, 1964 to the Legislature, the Governor and for Other Essential Purposes*, (Salt Lake City: State of Utah, 1964), 99. This is the only multi-level interchange identified by the USRC in literature of the period.

S.R. highway bridges make up approximately 37 percent of all extant bridges and culverts constructed between 1946 and 1965. At the end of the war Utah's primary road network of U.S. and S.R. highways consisted largely of a central north-south corridor extending from the Idaho border south to St. George and the Nevada and Arizona borders (U.S. 91 and 89), east-west routes crossing the Bonneville Salt Flats and Great Salt Lake Desert on the west and the agricultural counties of Duchesne and Uintah on the east (U.S. 40), and an east–west road extending from the Nevada to the Colorado border (U.S. 50).[240] No major new roads were constructed as a part of the war effort.

During the 1930s and 1940s Utah had made considerable strides in improving its primary road system through connection to other state borders, a program of paving and oiling road surfaces, and constructing bridges based on standard plans. But by the end of World War II, roads that had not been designated as part of the war-time Strategic Highway Network were, in the estimate of the USRC, in very poor condition. Many bridges and road surfaces on Utah's major U.S. Highways were 20 to 30 years old. In urban areas, inadequate 18- to 26-foot-wide pavements were carrying 5,000 to 10,000 vehicles per day.[241] Most bridges in the system were designed to carry 10-ton loads, a capacity that was rapidly exceeded by truck traffic in the postwar period. Bridges on these roads elicited particular concern where the USRC found "an alarming number of deficient structures."[242] Even though federal funding more than quadrupled from its pre-war level following the passage of the Federal-Aid Highway Acts, the USRC estimated that an equivalent program would be needed for 20 years in order to bring the state's U.S. and S.R. highways up to necessary standards to handle anticipated increases in traffic.[243]

During the late 1940s and early 1950s, the USRC approached this backlog with a program that placed a priority on resurfacing and repair of the road segments in the worst condition. These were defined as areas with narrow pavements, faulty design, or surfaces inadequate for traffic loads.[244] The USRC determined that for these road projects, state funding that was not needed for matching federal funds, maintenance, or operation would be used to temporarily address insufficiencies rather than to upgrade the roads to compliance with national standards for divided highways.[245]

By the mid-1950s increases in Federal-Aid Highway funding, state transportation gas tax funds, and the end of wartime material and labor shortages allowed the USRC to expand its focus from road repair to a more ambitious program of road and bridge building. By 1959 a $9.5 million

[240] State Road Commission, *Road Map of Utah*, 1940.

[241] Nineteenth Biennial Report, 1945-1946, 16.

[242] Nineteenth Biennial Report, 1945-1946, 17; Twenty-first Biennial Report, 1949-1950, 26.

[243] Nineteenth Biennial Report, 1945-1946, 16; State Road Commission of Utah, *Federal-aid for Highways in Utah*, ([Salt Lake City]: State Road Commission of Utah, 1958), 8.

[244] Twenty-first Biennial Report, 1949-1950, 7.

[245] Twenty-first Biennial Report, 1949-1950, 7.

investment was made on Interstate, U.S., and S.R. highways. Another $3.5 million was expended for secondary roads.[246] As a result, the April issue of the USRC publication *Utah Highways and Byways* reported that projects had increased 125 percent over the previous year.[247]

i. Bridges on U.S. and state highways in Utah

From the late 1950s through 1965, bridge building was an integral part of highway construction and the improvement of Utah's primary road system. A number of bridges were built as part of road improvements to serve the state's reclamation, mining, and military-industrial developments of the period. These bridges also provided access to recreational reservoirs and scenic attractions. For example, three extant bridges were constructed between 1959 and 1964 as part of a roadway improvement project to improve access to the Flaming Gorge Dam in Daggett County along S.R. 191 (Bridge 0C724, a steel beam and girder over the Flaming Gorge Dam Spillway; Bridge 0C 285, a continuous steel beam and girder over the Colorado River; and Bridge 0C 372, a steel thru arch over the Flaming Gorge Reservoir). Six extant bridges are located on U.S. 89 between Kanab and the Arizona border, as part of the roadway improvement project to reach the Glen Canyon Dam (Bridge 0E1107, a concrete culvert over Petrified Hollow Wash; Bridge 0C 298, a steel beam and girder over Blue Pool Wash; Bridge 0E1106, a concrete culvert over Seaman's Wash; Bridge 0D 605, a concrete rigid frame over Johnson Wash; Bridge 0D 604, a concrete rigid frame over Buckskin Gulch; and Bridge 0C 300, a steel beam and girder over the Paria River).[248]

The most prominent type of bridge and culvert on both U.S. and S.R. highways continued to be the concrete culvert, in both simple and continuous design. Postwar reinforced concrete culverts comprise 44 percent of the extant bridge and culvert population on U.S. Highways and 31 percent of the extant population on S.R. highways. Also well represented on U.S. and S.R. highways are steel beam and girder bridges, which represent 22 and 16 percent of postwar bridges on these routes, respectively. Additionally, reinforced concrete rigid frame structures comprise 20 percent of the structures on U.S. Highways and 14 percent of the extant population on S.R. highways. Additional information on these bridge types is provided in Section 4.

(e) City and county roads

Beginning in the 1930s the USRC assumed more responsibility for the funding and oversight of county bridge construction. The USRC's authority over county and municipal bridge building was enhanced by the 1944 Act, which made federal monies specifically available for "rural" and "urban" road projects. This shifted the decision-making balance in favor of the state, whose approval was required for most local projects.[249]

[246] This figure accounted for both Interstate and primary, secondary and urban roads.

[247] "Five-Man Commission Observes First Birthday," *Utah Highways and Byways* 1, no. 7 (April 1958): 1.

[248] Utah Department of Transportation, *Bridge Inventory Database*, 2009.

[249] Knowlton, *History of Highway Development in Utah*, 345-352.

During the postwar period, the amount of funds dedicated by the USRC to city and county roads more than doubled. Between 1944 and 1947, city and county road funds remained stable at $800,000 per year, at which time the state legislature increased the annual expenditure to $1,500,000. By 1960 the fund for city and county roads had risen to $2,000,000 annually.[250] Despite the rise in dollar expenditures on local roads through the 1950s, the combined city and county road budget represented only 16 percent of overall transportation expenditure in the state in 1961.[251]

i. Bridges on city and county roads

Bridges on county roads make up approximately 35 percent of all extant bridges and culverts constructed during the postwar period. The majority of structures on Utah county roads, built between 1946 and 1965, are steel beam and girder bridges, which comprise 26 percent of the structures on this roadway type. Additionally, reinforced concrete rigid frame (approximately 13 percent), prestressed concrete T-beams (approximately 13 percent), and timber structures (approximately 12 percent) are well represented on Utah county roadways. The remaining bridge types on county roads exhibit a range of types. Bridges on municipal roadways comprise approximately 21 percent of the bridges and culverts in the study pool. The most commonly used span types on municipal roadways include reinforced concrete slabs (approximately 25 percent), reinforced concrete rigid frames (approximately 20 percent), and prestressed concrete T-beams (approximately 11 percent). The remaining bridge types on municipal roads are varied. Additional information on these bridge types is provided in Section 4.

(4) State economic development and road and bridge construction

Economic development in the state played an important role in shaping state road and bridge priorities in the 1950s. In the annual reports to the state legislature and governor, the USRC emphasized that the road mileage built each year was constructed in the interest of industrial growth and tourism in the state.[252] Of major importance was the development of a number of federal reclamation projects on the Green and Colorado Rivers for purposes of promoting irrigation and hydroelectric power. The discovery and subsequent exploitation of uranium deposits in the vicinity of Moab, which was encouraged by the federal Atomic Energy Commission (AEC), also influenced road priorities in the southern part of the state. Expansion of existing copper mining operations involved road and bridge improvement projects west of Salt Lake City in the Magna area. Programs related to missile development and the Cold War promoted road construction in the vicinity of Brigham City. Finally, development of Interstate highways and improvement to U.S. and S.R. highways was increasingly recognized as a means of encouraging tourism, especially in the highly scenic south with its concentration of national

[250] “Burton Says State Should Safeguard Highway Funds,” *Utah Highway Progress* 3, no. 4 (30 March 1960): 1.

[251] “Financing Utah’s Highways,” *Utah Highway Progress* 4, no. 1 (12 January 1961): 1-2.

[252] *State of Utah, Compiled Digest of Administrative Reports for Fiscal Year Ended June 30, 1959 to the Legislature, the Governor and for Other Essential Purposes*, (Salt Lake City: State of Utah, 1959), 100.

parks and monuments, and its newly created recreational "lakes" that impounded water behind the region's many dams.

(a) Reclamation-related transportation projects

In 1956, the same year the Federal-Aid Highway Act launched construction of the Interstate system, the U.S. Congress approved the Colorado River Storage Project. The project was an enormous water development undertaking intended to harness and manage the Colorado River and its major tributary, the Green River. The project spread across a four-state area that included portions of Colorado, New Mexico, Arizona, and Utah. The purpose of the reclamation effort was to impound water for irrigation, hydroelectric power, and recreation. Utah's portion of the project was concentrated in the northeast and southern portions of the state. Immediate construction needs, as well as anticipated future traffic requirements, drove an ambitious program of road building, repair, and bridge construction to facilitate the reclamation boom.[253]

The USRC's newsletter, *Utah Highway Progress*, announced in June 1959 that the USRC was giving high priority to constructing new roads to dam sites.[254] By way of illustration, the newsletter cited the completion of a new road and bridge connection between the town of Dutch John and the construction site of the Flaming Gorge Dam along former S.R. 44 (now S.R. 191). Part of this roadway project included a suspension bridge (non-extant) spanning the Green River one mile upstream from the Flaming Gorge Dam. Before the new road construction, the trip between the Dutch John and the Flaming Gorge Dam was 97 miles each way. In 1960 completion of S.R. 44/S.R. 191 between Dutch John and the dam construction site reduced this travel distance by half. This project was part of a $3 million federal aid program of highway work in Uintah and Daggett Counties that was intended to create better access to the dam.[255]

By far the largest reclamation-related project was the $5 million highway improvements project on U.S. 89 from Kanab to the Arizona state line to provide access to the Glen Canyon Dam construction site. At the Cock's Comb area of the route, an opening 180 feet deep and 800 feet long was cut through solid sandstone formations. This 57-mile-long roadway segment opened in October 1958 to facilitate hauling materials for dam construction.[256] Six extant bridges are located along this segment of U.S. 89, all of which were built in 1958. The bridges were: Bridge 0E1107, a concrete culvert over Petrified Hollow Wash; Bridge 0C 298, a steel beam and girder over Blue Pool Wash; Bridge 0E1106, a concrete culvert over Seaman's Wash; Bridge 0D 605, a concrete rigid frame over Johnson Wash; Bridge 0D 604, a concrete rigid frame over Buckskin

[253] Thomas Alexander, *Utah the Right Place,* (Salt Lake City: Gibbs Smith Publishers, 2007), 385-387; Marc Reisner, *Cadillac Desert: The American West and Its Disappearing Water,* (New York: Penguin Books, 1986), 264-316.

[254] "Access Roads to Dams Get Attention of State Road Commission," *Utah Highway Progress* 2, no. 6 (22 June 1959), 1-2.

[255] "District 6," *Utah Highways and Byways* 3, no. 5 (February 1960): 4.

[256] "Glen Canyon Road Gets Official Opening," *Utah Highways and Byways* 2, no. 1 (October 1958); 4.

Gulch; and Bridge 0C 300, a steel beam and girder over the Paria River.[257] Road improvements were also made to S.R. 24 and S.R. 47 near the Arizona border in anticipation of the future tourist traffic attracted to recreation on Lake Powell, and in Capitol Reef National Park and Monument Valley.[258]

Less spectacular than Flaming Gorge and Glen Canyon, the Weber Basin Water Conservancy District created a large network of reclamation projects across the Weber and Provo River basins that consisted of reservoirs, canals, irrigation and drainage systems, and hydroelectric dams constructed by the Bureau of Reclamation between 1952 and 1969. Pineview, Willard Bay, and five other reservoirs or storage basins also provided recreational opportunities. [259] A number of bridges, primarily spanning irrigation canals within the water conservancy district system, were constructed between 1958 and 1962. In 1959 four miles of access road to Pineview Dam between Eden and Liberty east of Ogden were completed along S.R. 168.[260]

Reclamation projects were responsible for some of the most spectacular bridges built in Utah in the late 1950s and 1960s due to the spanning of deep gorges and large rivers, such as the Green and Colorado Rivers. Utah's longest single-span bridge from the period, completed as a part of the Flaming Gorge dam project, was a specially designed and fabricated steel arch bridge (Bridge 0C 372) spanning the 200-foot-deep Cart Creek Canyon, 40 miles north of Vernal on S.R. 191.[261]

(b) Transportation and mining efforts

Mining and natural resource extraction were another focal point for road repair and construction during the study period. Utah is rich in copper, uranium, oil, and coal deposits. Of these natural resources, only copper had been extensively exploited prior to World War II. Changes in the national economy, government policy, and geological exploration following the war triggered major booms in the mining and extraction of these resources beginning in the mid-1950s and extending into the 1970s.

The discovery of nuclear fission in the Manhattan Project during the war and the race for nuclear dominance in the emerging Cold War placed an emphasis on the discovery of a domestic source of uranium which had previously been imported from Africa. In 1948 the AEC announced premiums for significant discoveries of uranium ore. These premiums set off a rush of speculation in Utah on the Colorado Plateau that had long been recognized as rich in uranium and radium deposits. The town of Moab became a center of the boom, which lasted from 1948

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[257] Utah Department of Transportation, *Bridge Inventory Database*, 2009.

[258] "Districts in the Highway Department: District 3," *Utah Highways and Byways* 3, no. 2 (November 1959): 2.

[259] Weber Basin Water Conservancy District Website, http://www.weberbasin.com/history.php (accessed 21 July 2010.

[260] "District 1," *Utah Highways and Byways* 1, no. 12 (September 1958): 4.

[261] "Cart Creek Bridge construction Near Flaming Gorge Dam," *Utah Highways and Byways* 5, nos. 11-12 (August-September 1962): 4.

until 1971, when the AEC ended their program.[262] By 1955 approximately 800 mines were producing high-grade uranium ore, with Utah accounting for nearly nine million tons of the production. [263] A number of larger mining operations were established; the best known was the Mi Vida in the Lisbon Valley southeast of Moab. This was the site of the first major uranium strike in the state. Other well-known mines included the Delta Mine northwest of Hanksville and the Happy Jack Copper mine out of Monticello. Road improvements were undertaken on U.S.191 between Moab and Monticello, and included a number of bridges constructed between 1950 and the early 1960s.

In this same period oil exploration became increasingly prominent, particularly in the Aneth-Montezuma Creek area. Beginning in 1953 Humble and Shell oil companies began negotiation with the state and the Navajo Nation for oil leases, with the first well drilled in 1956. Road and bridge improvements were undertaken along U.S. Route 163 near Mexican Hat, a major access point for the Navajo Tribal Lands in San Juan County.[264] During this period of natural resource speculation, the USRC estimated that as many as 1,000 miles of road were improved to serve mining and oil developments in the southeast part of the state.[265]

In the northern part of the state efforts were undertaken between Magna and Garfield along S.R. 201 in 1961 to provide better access to the Kennecott Copper Corporation's mining operations in Bingham Canyon, located in the Oquirrh Mountains 25 miles southwest of Salt Lake City. In an effort to facilitate traffic to the largest copper mine in the world, the USRC improved S.R. 201 by eliminating the dangerous curves on the older stretch of road. The road improvement, which included four bridges built between 1963 and 1964, involved a massive amount of grading and earth-moving for which special equipment was required. The USRC acted in "close cooperation" with the Kennecott Copper Corporation, which provided one million yards of dirt for the project. Extant bridges along this segment of S.R. 201 related to the Kennecott Copper Corporation's mining efforts include: Bridge 0E 1272, a continuous concrete culvert built in 1963; Bridge 0V 737, a concrete rigid frame built in 1964; Bridge 2C 371, a steel beam and girder bridge built in 1964; and Bridge 4C 371, a steel beam and girder bridge built in 1964.[266]

(c) Transportation and the U.S. missile program

The Cold War missile program played an important economic role in the post-World War II years. The Utah Test and Training Ranges and the Dugway Proving Ground in the northwest corner of

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[262] Thomas Alexander, *Utah the Right Place,* 370; "District 6," *Utah Highways and Byways* 3, no. 3 (December 1959): 3.

[263] Utah Historical Society, "Uranium Mining in Utah," Utah History to Go website, http://historytogo.utah.gov/utah_chapters/utah_today/uraniummininginutah.html (accessed 13 September 2010.)

[264] Utah Department of Transportation, Bridge Inventory.

[265] "District 6," *Utah Highways and Byways* 3, no. 3 (December 1959): 3.

[266] "New Section of Magna-Garfield Highway Ahead of Schedule," *Utah Highways and Byways* 4 nos. 9-10 (June-July 1961): 3; Utah Department of Transportation, *Bridge Inventory Database*, 2009

the state had been important military installations during World War II and continued to play a an important role in national defense during the Cold War and the site of a number of “top-secret” Department of Defense (DOD) projects. Thiokol Chemical Corporation, a major DOD industrial contractor, established its headquarters in Brigham City in close proximity to these military installations. A producer of rocket propellant, Thiokol purchased a large amount of land in Utah for its rocket test range and rocket fuel production. In 1959 the USRC conducted an origin and destination study for the Thiokol plant in Corinne, north of Salt Lake City and west of I-15. This study resulted in improvements to a 20-mile section of S.R. 83 that connected Brigham City and I-15 to the Thiokol plant at Corrine in 1961.[267] However, no extant bridges are found on this route.

(d) Road safety improvements

Other highway projects were directed toward eliminating dangerous road segments and providing better access to rural communities. Examples of roadway improvement projects related to this theme include the 1958 improvements to S.R. 54 from Escalante to Boulder, one of the most remote locations in the state; improvements to U.S. 80 in Kane County through the Cedar Mountains, involving extensive blasting though sections of solid rock along the route; and improvements to U.S. 89 and S.R. 218 through the Cache Valley, including the replacement of a large bridge over the Bear River (Bridge 0F 8), providing better access to Logan and Utah State University.[268]

From the beginning of the twentieth century through 1965 Utah made steady progress toward improving the state’s network of highways and bridges. The state was increasingly influenced by federal programs, standards and funding requirements. By the end of the mid 1960s Utah had largely achieved the goals first articulated in the early decades of the twentieth century to modernize its highway system, connect the state to U.S. Highway and later interstate system, and introduce modern materials and construction design in its bridges. The next section will discuss national bridge design and materials based on the extant bridges constructed in Utah through 1965.

[267] “Defense Road Dedicated,” *Utah Highways and Byways* 4, nos. 11-12 (August-September, 1961): 8.

[268] “Cache Valley Construction Opens Recreation Areas,” *Utah Highways and Byways* 2, no. 12 (September 1959): 3; “Kane County Project Eliminates Dangerous Section of US Highway 89” *Utah Highways and Byways* 5, nos. 4-5 (January-February 1962): 3.

5. Bridge Design and Construction

This section on bridge design and construction is organized into a discussion of four topics: national design standards and their influence on bridge design in Utah; the role of the USRC and Engineering Department in bridge design and construction; bridge types designed and constructed in Utah, organized by bridge-building material with examples of bridges where appropriate[269]; and bridge aesthetics. The inventory includes 619 bridges and culverts with structure lengths greater than 20 feet constructed through 1965. Although bridges carrying the Interstate highway system are excluded from National Register evaluation under this study, a general analysis of the 160 extant Interstate bridges was conducted to provide an appropriate context.

A. Influence of national design standards for bridges

Design and construction of bridges nationwide, and in Utah, were influenced by standards created by national transportation organizations. Two such organizations played a prominent role in setting and disseminating design standards. Plans and guidance developed by the BPR and professional transportation organizations, like the AASHO, were instrumental in establishing federal transportation policy and disseminating information regarding new materials and technology, standard bridge designs, and best practices to state departments of transportation, which were then frequently adopted in bridge design.

The series of Federal-Aid Acts, and in particular the 1956 Federal-Aid Act, formalized efforts of the BPR and AASHO to work together on national design standards. The standards were meant to ensure national uniformity of design and eliminate at-grade crossings.[270]

Additionally, professional organizations such as the ACI, American Society of Civil Engineers (ASCE), and the Prestressed Concrete Institute (PCI) contributed significantly to the development of bridge standards. These organizations are discussed in more detail below.

(1) Bureau of Public Roads[271]

An overview of activities of the BPR and its predecessors is presented to provide a context for understanding national bridge-building guidance that influenced states across the U.S., including Utah. The BPR is the federal agency that provided state departments of transportation guidance on bridge design, material use, and innovations.

In 1895 the ORI was established in the USDA to promote the Good Roads Movement, advocate technical expertise, prepare county road maps, and provide information on road construction

[269] Bridge examples serve only to illustrate the discussions of material innovations and bridge types and do not indicate significance under National Register criteria.

[270] Weingroff, "Federal-Aid Highway Act of 1956: Creating the Interstate System," Federal Highway Administration.

[271] Unless noted, the national context of the role of the BPR in this section is based on Mead & Hunt's research in the U.S., including *Indiana Bridges Historic Context Study, 1830s -1965* completed by Mead & Hunt in 2007, 49-50. Available at http://www.in.gov/indot/files/INBridgesHistoricContextStudy1830s-1965.pdf.

through the circulation of bulletins, technical testing of materials, and the construction of demonstration roads. The agency, which was the predecessor to BPR, believed that research and a scientific approach to highway construction would provide guidance to improve the often miserable road conditions of the early twentieth century, including inadequate bridges. In 1910 the now renamed Office of Public Roads (OPR) established a Division of Bridge and Culvert Engineering that began to construct demonstration bridges, publish bridge construction information, and prepare standard specifications and plans for various bridge types for state and local use.

The OPR initially faced difficulties in receiving public support because the centralization of design at the state and federal level challenged the practice of design by local and state jurisdictions. The OPR provided an important resource as bridge building increasingly shifted from local to state and federal control with programs such as offering “free” bridge design to local governments in the 1910s.

To disseminate research, BPR began the monthly publication *Public Roads—A Journal of Highway Research* in 1918, which continues to be published today by the FHWA. Provisions of the Federal-Aid Act of 1921 kept BPR in control of national highway and bridge design. During this period, BPR placed a high priority on research, which was viewed as fundamental to good highway and bridge design.

During the 1920s and through 1965, BPR officials focused on cooperative research with the National Research Council, Highway Research Board, and AASHO. Moreover, state highway department testing facilities and laboratories, which BPR was responsible for, and engineering colleges became research partners with the Highway Research Board.[272] As a result, BPR increasingly provided important guidance on use of new materials and design innovations by incorporating the results of testing that was done throughout the U.S. and internationally.

BPR defined national standards and specifications for transportation facilities, approved states’ proposals for road and bridge construction projects utilizing federal funds, provided guidance on road and bridge construction, and prepared and distributed standard bridge plans. This information was disseminated through publications of research studies and design manuals.[273] Standard plans and other BPR publications significantly influenced state department of transportation activities and design practices. The effect of BPR standards for bridges is evident in Utah when, in 1918, changes in loading standards made the Engineering Department’s standard plans from 1913 obsolete. These changes required the department to revise its standards to bring them into conformity with national guidelines, resulting in new standard designs for many bridge types in 1923.[274] Every few years, the BPR updated their standards and

[272] Seely, 109-114.

[273] "Brief History of the Direct Federal Highway Construction Program," Federal Highway Administration, http://www.fhwa.dot.gov/infrastructure/blazer01.htm (accessed 12 December 2009).

[274] Fraser, 47.

specification and issued revised editions. The context generally notes when BPR revisions were made that affected state bridge design and were noted by the USRC in its biennial reports; however, it is likely that as regular BPR standards were released, USRC made incremental and gradual changes to reflect new designs after its initial release of standards for bridge types listed in Table 1 below. See Section B for a discussion on the USRC and standard plans.

The BPR published its first edition of national standard bridge plans in 1953 and periodically updated these plans to reflect new technologies and materials. The 1956 edition includes plans for a variety of highway superstructures of varying span lengths and roadway widths, including I-beams, plate girders, and concrete slabs. Bridge types included in the BPR standard plan set reflect established bridge types and designs commonly constructed by this date. A summary of these national standard bridge plans, issued in 1956, is included in Table 1. The majority of these bridge types were used in Utah.

Table 1. BPR Standard Plans (1956)[275]

Superstructure Type	Roadway Width (feet)	Maximum Span Length (feet)
I-beams (simply supported)	24	80
	28	70
I-beams (composite, simply supported)	24 and 28	100
I-beams (three-span continuous)	24 and 28	80-100-80
Riveted deck plate girders	24 and 28	140
Welded deck plate girders	24 and 28	140
Reinforced concrete slabs	24 and 28	35
Reinforced concrete T-beams	24 and 28	60
Reinforced concrete box girders	24	120
Precast concrete deck units with channel sections	24 and 28	30
Pre-tensioned precast concrete deck units with cylindrical voids	28	45
Box girder (also known as pre-tensioned precast concrete deck units with hollow box sections)	28	70
Pre-tensioned prestressed concrete I-beams	24 and 28	70
Post-tensioned prestressed concrete I-beams	24 and 28	100
Five forms of timber spans (including solid timber joists, laminated timber, and glue-laminated timber joists)	24	65

[275] United States Bureau of Public Roads, *Standard Plans for Highway Bridge Superstructures*, 2d ed. (Washington, D.C.: Government Printing Office, 1956), n.p.

Every few years, the BPR updated their standard plans and issued revised editions to include new and improved bridge plans. In 1962 the BPR expanded its standard plans to a five-volume series, including concrete superstructures, structural steel superstructures, timber bridges, continuous bridges, and pedestrian bridges. Bridge types are discussed in more detail below.

The BPR also offered guidance on the use of new materials, incorporating results of testing that was done throughout the country and internationally. Guidance on prestressed concrete in the early 1950s was provided to state departments of transportation in the BPR's *Criteria for Prestressed Concrete Bridges* in 1954. This volume highlighted best European practices prior to the material's widespread use in the United States. See Section 5.C.(1)(b) for further discussion of prestressed concrete.

(2) American Association of Highway Officials

AASHO was another organization that provided state departments of transportation guidance on bridge design and technical innovations. AASHO, the predecessor to AASHTO, a professional organization of state highway officials, has a long history of defining and disseminating standard practices for road and bridge engineering. State highway officials established this national professional organization in 1914 to allow for the discussion of issues related to road construction, including legislation, economics, and design. As early as 1921, AASHO had established a subcommittee on bridges and structures with the following mission:

> Cooperate with the different States and Federal departments and other associations, societies, and institutions with a view to assisting in establishing uniform standard methods of construction and maintenance and in standardizing as much as possible the various kinds of construction used in connection with highway development.[276]

In working toward its mission, AASHO published its first set of bridge specifications in 1931, although informal versions were available as early as 1926. AASHO's bridge specifications were intended to be a model for state highway departments, providing minimum requirements of standard practice for bridge construction that could be tailored to meet local needs. AASHO specifications became the industry standard for guidance on bridge design and construction. Specifications were also developed for "ordinary" highway bridges with spans typically less than 300 feet.[277]

During the 1920s-1940s, AASHO committees were generally headed by BPR officials, and bridge and road specifications released were frequently prepared by federal engineers. Together, BPR and AASHO established and implemented consensus design standards while seeking to standardize road and bridge-building practice itself.[278] Every few years, AASHO updated their

[276] Johnson, 105.

[277] American Association of State Highway Officials, *Standard Specifications for Highway Bridges*, 5th ed. (Washington, D.C.: American Association of State Highway Officials, 1949), xxiv.

[278] Seely, 121-126.

standards and specifications and issued revised editions. The context generally notes when AASHO revisions were made that affected state bridge design and were noted by the USRC; however, it is likely that as regular ASSHO standards were released, USRC made incremental and gradual changes to reflect new designs after its initial release of standards for bridge types. See Section B for a discussion on the USRC and standard plans.

Like the BPR, AASHO also published roadway and bridge standards to address varying traffic needs, loads, and speeds. In 1945 AASHO adopted specific recommended design standards for highways. The AASHO guidance emphasized steel, reinforced concrete, and masonry bridges.[279] AASHO also issued guidance and policies on grade-separation structures throughout the subject period. In 1944 AASHO published *A Policy on Grade Separations for Intersecting Highways*, which recommended grade separations at intersections in rural areas, where higher traffic counts warranted this safety measure.[280] The policy recommended that deck-type structures, or those structures in which the structural system lies entirely beneath the bridge deck, span as much of the roadway that passes underneath it as possible. The deck-type bridge was preferred because it has few intermediate supports and provides drivers a limited sense of restriction.[281]

Changes in standard specifications were reviewed and changes made annually by AASHO.[282] New versions were released periodically, in the introduction to the seventh edition in 1957, AASHO stated that “the vast amount of research and development of both steel and concrete structures practically dictates the necessity of revising the specifications every three or four years.”[283] Regular updates reflected rapid changes in new materials developed during this period. Where applicable, the USRC referenced the use of AASHO standards within their own *Standard Specifications for Road and Bridge Construction*, which were issued in 1952 and 1960.[284]

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[279] American Association of State Highway Officials, *Policies on Geometric Highway Design* (Washington, D.C.: American Association of State Highway Officials, 1945, reprinted 1950), 4.

[280] George L. Carver, "The Interstate System Survey," in *Proceedings of the Twenty-Third Annual Short Course in Highway Engineering*, ed. Fred J. Benson (College Station, Tex.: Texas Engineering Experiment Station, A&M College of Texas, 1949), 54-55.

[281] American Association of State Highway Officials, *A Policy on Grade Separations for Intersecting Highways* (Washington, D.C.: American Association of State Highway Officials, 1944), 43.

[282] U.S. Department of Transportation, Federal Highway Administration, “Bridge Technology” at http://www.fhwa.dot.gov/bridge/lrfd/plan.cfm, accessed 22 April 2011.

[283] American Association of State Highway Officials, *Standard Specifications for Highway Bridges*, 7th ed. (Washington, D.C.: American Association of State Highway Officials, 1957), xxiii.

[284] See Utah State Road Commission, *Standard Specifications for Road and Bridge Construction* (Salt Lake City: Utah State Road Commission, 1952); Utah State Road Commission, *Standard Specifications for Road and Bridge Construction* (Salt Lake City: Utah State Road Commission, 1960).

Several innovations were introduced in AASHO specifications during the postwar period. Incorporated innovations trace new technologies that were embraced by the bridge construction industry. In 1949 a design method for plate girders was introduced that permitted thinner webs for long girders.[285] The 1957 specifications included new discussions on the use of high-tensile bolts and concrete box girders. Specifications were also added for structural steel welding that were “developed largely to meet the demand for weldable steel for highway bridges.”[286] Although the AASHO committee had studied prestressed concrete design and construction, prestressed concrete was not included in the 1957 specifications. Continuing research and experimentation with the material resulted in developments that were changing too quickly to address in this version.

Prestressed concrete was included in AASHO standard specifications for the first time in 1961. The guidance was largely based on the joint ASCE and ACI Committee on Prestressed Concrete report of 1958.[287] Other significant revisions in the 1961 edition, based on the latest research and developments, addressed the following topics: neoprene (elastomeric) bearing plates, reinforced concrete, plate girders, and high-strength bolts.[288]

In 1956 AASHO adopted *A Policy on Design Standards, Interstate System*, which also included standards for crossroad overpasses and underpasses. As in earlier highway standards, AASHO recommended that bridges and overpasses be of deck construction to fit the overall alignment and profile of the highway. For all structures of 150 feet or less, including grade separations, the bridge was recommended to be the full width of the roadway, including pavement and shoulders.[289] In 1957 AASHO published *A Policy for Arterial Highways in Urban Areas*, which built upon the policy for rural highways and included substantial guidance on interchange design and grade separations in metropolitan areas.[290] AASHO provided additional recommendations for grade-separation structures in its 1954 and 1965 editions of *A Policy on Geometric Design of Rural Highways*. In the 1965 edition, AASHO continued to advocate the use of deck-type structures for overpass highways and recommended prestressed deck designs for longer spans. Additional AASHO recommendations included that structures be visible to approaching traffic

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[285] Johnson, 105.

[286] American Association of State Highway Officials, *Standard Specifications for Highway Bridges*, 7th ed. (1957), xxiii.

[287] American Association of State Highway Officials, *Standard Specifications for Highway Bridges*, 8th ed. (Washington, D.C.: American Association of State Highway Officials, 1961), xxiii.

[288] American Association of State Highway Officials, "Geometric Design Standards for the National System Interstate and Defense Highways," *American Highways* (October 1961): n.p.

[289] American Association of State Highway Officials, *A Policy on Design Standards: Interstate System* (Washington, D.C.: American Association of State Highway Officials, 1956), 5-6.

[290] American Association of State Highway Officials, *A Policy on Arterial Highways in Urban Areas* (Washington, D.C.: American Association of State Highway Officials, 1957), n.p.

both day and night, and that they be aesthetically pleasing.[291] Many of the policies, research information, and specifications developed and promoted by AASHO and the BPR were incorporated into the USRC's postwar bridge program.

(3) American Concrete Institute[292]

The ACI was established in 1904 and continues to function today. The history of ACI follows innovations in the concrete industry. Concrete production in the early in the 20th century, was characterized by few standards that resulted in an inconsistent product. In 1904 Charles Brown, editor of *Municipal Engineering*, established an organization to discuss concrete-related issues. By 1905 a convention was held in Indianapolis, and the group called themselves the National Association of Cement Users with the goal of disseminating and promoting the best methods to be employed in the various uses of cement. The group encouraged papers and studies on the production and uses of cement. In 1913 the group changed its name to the American Concrete Institute, but its goals were the same. By this time the ACI had a committee that had produced more than 18 standards and recommended practices.

During the following decades, the work of the institute continued and it established the *Journal of the American Concrete Institute* (*ACI Journal*) to disseminate much of the research work completed in the production and use of concrete and ACI Building Codes. In fact by early 1930s, "municipalities and organizations had adopted, either in full or part, one of the Institute Codes (editions of 1925, 1927, or 1928), or permitted designs based on them." ACI and its publications have provided industry standards since the 1930s and continue today. USRC engineers were involved with the ACI and no doubt applied relevant concrete advances and standards in bridge construction.

(4) Prestressed Concrete Institute

With the new material gaining acceptance, during the 1950s professional organizations such as the PCI and the ACI promoted the use and benefits of prestressed concrete in bridge construction. These groups disseminated information about prestressed concrete to bridge engineers and contractors through conferences, symposiums, and publications such as the *PCI Journal* and *ACI Journal*. Articles that were written by bridge designers, fabricators, manufacturers, and university professors touted the advantages of prestressed concrete. With prestressed concrete in its infancy in the early to mid-1950s, articles such as L.E. Hills' 1956 "Prestressed Concrete Now a Standard Product" illustrated that bridge contractors and consultants were reluctant to utilize prestressed concrete because they did not know how to

[291] American Association of State Highway Officials, *A Policy on Geometric Design of Rural Highways*, (Washington, D.C.: American Association of Highway Officials, 1954), n.p.; American Association of State Highway Officials, *Standard Specifications for Highway Bridges*, 9th ed.(Washington, D.C.: American Association of State Highway Officials, 1965), 502.

[292] This section adapted from the American Concrete Institute, "History of ACI" accessed 22 April 2011, available at http://www.concrete.org/members/mem_info_history.htm.

estimate the costs of designing and building prestressed concrete bridges.[293] In addition, articles by prestressed concrete proponent T.Y. Lin, including his 1956 "Economics of Prestressed Concrete" article, compared the cost of prestressed concrete bridges with reinforced concrete and steel bridges on small, medium, and long spans. Lin's article also explained the differences and advantages of using pre-tensioned and post-tensioned members on bridges.[294]

The BPR published engineering specifications for prestressed concrete bridges in its 1954 publication *Criteria for Prestressed Concrete Bridges* and issued standard plans for prestressed, pre-tensioned concrete I-beams in 1956.[295] However, AASHO did not include specifications for prestressed concrete until 1961 due to ongoing research and innovations throughout the 1950s by organizations such as the BPR, PCI, and ACI.[296] In 1963 AASHO and the PCI published recommendations and plans for standard shapes of prestressed concrete I-beams, piling, slabs, and box beams. The purpose of the plans was to "establish a limited number of simple, practical sections leading to uniformity and simplicity of forming and production methods." Plans were included for I-beams with span lengths of 30 to 100 feet, box beams with spans up to 103 feet, and slabs with spans up to 55 feet.[297]

B. The Utah State Road Commission

(1) Standard bridge specifications and plans

In Utah, the USRC's Engineering Department began "systematizing design and specifications according to modern engineering practice, and the preparing of standard plans for bridges and culverts that would be suitable for the different conditions and localities in which they might be required" with the stated of goal of establishing standard plans and specifications by 1911.[298] To accomplish this, a large amount of time was spent looking to other state highway commissions in the U.S.[299] By 1913 the Engineering Department of the USRC had "standardized all bridge designs" from 20 to 100 feet and had produced the book titled *Standard Culvert Plans*, which contained fifty different culvert designs. Among the bridge types mentioned were timber and steel trusses, concrete slabs, and concrete girders (see Table 2).[300]

[293] L.E. Hill, "Prestressed Concrete Now a Standard Product," *PCI Journal* May 1956: 52.

[294] T.Y. Lin, "Economics of Prestressed Concrete," *PCI Journal* December 1956: 48-56.

[295] United States Bureau of Public Roads, *Criteria for Prestressed Concrete Bridges* (Washington, D.C.: Government Printing Office, 1954).

[296] American Association of State Highway Officials, *Standard Specifications for Highway Bridges*, 8th ed. (1961), xxiii.

[297] *Tentative Standards for Prestressed Concrete Piles, Slabs, I-Beams and Box Beams for Bridges and an Interim Manual for Inspection of Such Construction* (Washington, D.C.: American Association of State Highway Officials, 1963), n.p.

[298] Second Biennial Report, 1911-1912, 14.

[299] Second Biennial Report, 1911-1912, 14.

[300] Third Biennial Report,1913-1914, 29.

Table 2. Bridge Types with USRC Standards [301]

Superstructure Type and NBI Structural Code	Date	Span Length (feet)
Warren pony truss	1913	45-100 and greater
Concrete and steel culverts	1913	Up to 100 feet
Concrete slab	1913	5-20
Concrete girder	1913	25-40
Timber Howe truss	1913	20-80
Steel multi-beam and girder	1923	Up to 100 feet*
Timber stringer	1923	Up to 100 feet*
Reinforced concrete T-Beam	1923	Up to 100 feet*

** Lengths ranges were not revealed during research for the 1923 standards; it is likely the USRC continued designing structures up to 100 feet and spans requiring lengths greater than 100 feet were developed an individual basis listed as "Special Bridge Designs" in the biennial reports.*

Beginning in the 1910s and 1920s the USRC and Engineering Department staff became active in a number of national highway organizations, including AASHO, the American Highway Association, and the ACI.[302] These activities helped the USRC and its employees stay abreast of what was happening in the wider world of highway engineering and materials.

By 1918 the USRC bridge department indicated that they were making federal standards widely available in the form of standard specifications published and distributed to staff. These standards went to the field agents and engineers who oversaw construction and were in charge of making sure that standard plans and appropriate materials standards were being followed. In 1918 the Engineering Department announced that their structural steel specifications had been revised to modern standards.[303] It also reported that changes in the BPR loading standards for bridges made many of their previous plans obsolete and it required a great deal of work to bring their standard plans into conformity with national guidelines. This need for revision slowed down bridge work over the next year. The new standard designs were completed in 1923 and included plans for steel and timber stringers, steel and timber trusses, concrete T-beams and slabs and steel plate girders (see Table 2).[304] In 1927 the USRC again revised its loading standards to

[301] Third Biennial Report, 1913-1914, 14; Eighth Biennial Report,1923-1924, 29-32; Fraser, 46. The USRC biennial reports state that bound books with blue line draws were developed and distributed state road agents and engineers of over 50 culverts and many bridge designs beginning by 1913; however, copies of were not found during research. Instead, the descriptive information and select reproductions of these draws from the USRC biennial reports serves as the basis of this analysis and Table 2.

[302] Knowlton, 164.

[303] Fifth Biennial Report, 1917-1918, 19.

[304] Fraser, 47.

conform to new recommendations from AASHO.[305] The USRC adopted AASHO standards for road and shoulder width and for four-lane divided highways at the end of the 1930s, which may have led to bridge widening and adopted standard bridge loading standards.[306] Apart from the release of standards plans in 1913 and 1923, research and USRC biennial reports do not reference major subsequent revisions to the standard plans. Based on the revisions to the standards in 1927 and again by 1938 to accommodate changes in BPR and AASHO recommendations, it is likely USRC made frequent and gradual updates from the 1930s and into the 1950s when national versions of these standards were released to serve as a basis for standard bridge design.

The USRC also published *Standard Specifications for Road and Bridge Construction.* Research found versions for 1944, 1952, 1953, and 1960, of *Standard Specifications for Road and Bridge Construction*, but earlier versions were not identified. These publications were state-oriented specifications on the fabrication, construction, and erection of concrete and steel bridges. Information related to the introduction of innovations or use of materials in bridge design has been incorporated into the bridge type discussions below.

(2) Materials and testing

The Act of 1909 that created the USRC gave them authority to establish a materials testing laboratory. Early in the USRC organization, it established a highway testing program through the University of Utah and Utah State University.[307] Beginning in 1918 USRC's state testing laboratory cooperated with the BPR national testing laboratory and the Highway Research Board of the National Research Council, but it is unclear what initiatives Utah adopted as a result.[308] By 1919 the USRC established its own testing facilities, first in the basement of the state capital and, shortly after that, in its own facility. Research found that the work of the testing laboratory was primarily to test and verify the quality of materials used by road contractors and to confirm that USRC standard specifications were being observed on construction jobs. The state testing laboratory appears to have focused on evaluating road surface materials.[309] Research found no major achievement and no discussion on testing related to bridge design or materials.

Beginning in 1939 the USRC adopted a new approach for steel beam bridge design incorporating the use of large-scale welding. The new approach involved severing the lower flanges, which were curved and welded to the beam. The new approach added strength and reinforcement and resulting in beams with arched lines and marked the beginning of the application of large-scale welding on highway bridges in Utah. The earliest bridges employing this design were Rich

305 Tenth Biennial Report, 1927-1928, 74.

306 Fifteenth Biennial Report, 1937-1938, 18.

307 Knowlton, 140.

308 Fifth Biennial Report, 1917-1918, 28.

309 Thirteenth Biennial Report, 1934, 41.

County Bridge 0C 205 (1941), Utah County Bridge 0C199 (1941), and Weber County Bridge 0C 175 (nonextant).[310]

Bridge 0C 205, Rich County at Mile Post 134.176, carrying SR-30 over the Bear River – an example of steel stringer/multi-beam or girder associated with early use of large-scale welding in Utah

C. Bridge materials and types

(1) Reinforced and prestressed concrete

Concrete was first used in U.S. bridges as early as the 1870s. Initially used without reinforcement, plain or mass concrete worked solely under compression and was only applicable to the arch form. Concrete became more common for bridge building in the twentieth century as methods of reinforcement with metal wire and steel were introduced to improve its strength. By the 1930s prestressing was developed as a method of concrete reinforcement, becoming popular in the 1950s. Prestressing involves compressing concrete with heavily loaded wires or bars to improve strength. Reinforced and prestressed concrete are used in several types of highway bridges—from arches to beams and girders. Concrete allows a great deal of flexibility in bridge form.

Reinforced concrete had been in widespread use nationally and in Utah since the early twentieth century, but prestressed concrete rapidly became a significant new material during the postwar period. The following section addresses the use of both reinforced concrete and prestressed

[310] Sixteenth Biennial Report, 1939-1940, 34-35; Fraser, *Utah Historic Bridge Inventory Data*,

concrete during the period and the bridge types that employed these materials, including rigid frame, slab, beam or girder, arch, and culvert.

Of Utah's extant bridges constructed through 1965 subject to evaluation, 56 percent are reinforced concrete and nine percent are prestressed concrete.

(a) Reinforced concrete

Reinforced concrete was used by the USRC throughout the period in a variety of bridge types. Concrete became more common for bridge building after methods of reinforcement were introduced in the late nineteenth century, improving concrete's tensile strength (resistance to lengthwise stress). For example, in the Melan system developed by Joseph Melan of Austria in the 1890s, parallel steel I-beams are embedded into concrete. I-beams are joists or girders with short flanges and a cross section formed like the letter "I" to provide greater strength.

Reinforced concrete is used in several types of highway bridges, including rigid frame structures, arches, slabs, and beams and girders, because it allows a great deal of flexibility in bridge form. For example, arches can span comparatively longer distances than slabs and beams and girders, but beams and girders can be built quickly and efficiently. The USRC indicated a preference for the adoption of reinforced concrete construction as early as 1910.[311] Concrete continued to be used in bridge construction during the 1920s and the 1930s. By 1930 the USRC commented on the frequent use of reinforced concrete for the following reason:

> …the availability of local materials of construction is always a factor in determining the type of structure to be built, since, if suitable sand and gravel for concrete is available locally, and a long and expensive haul would be required for structural steel, it is immediately apparent that for short spans a concrete superstructure would be more economical than a steel superstructure, providing other conditions at the site in question did not show otherwise.[312]

Concrete was among the most commonly used materials in the USRC reports; particularly plentiful was the concrete T-beam and concrete rigid frame.

(b) Prestressed concrete

There are two types of prestressed concrete –pretensioned and post-tensioned. To form pretensioned concrete, steel reinforcing rods are stretched and placed into forms and held under stress until the concrete is poured. Once the concrete is hardened, it holds the steel to its stressed length. Post-tensioned concrete is formed when the steel rod or wire is inserted through open recesses or along the outside of the concrete member and is stretched and attached with a permanent anchor to maintain stress.

Experiments in prestressing concrete occurred as early as the late nineteenth century, but it was decades before it was practical to use. In 1934 research on prestressed concrete beams

[311] First Biennial Report, 1911-1912, 18.

[312] Fifteenth Biennial Report, 1937-1938, 33.

evaluated stress distribution and compared prestressed concrete with conventionally reinforced concrete.[313] State departments of transportation in Florida, Tennessee, California, and Pennsylvania were involved in early development and use of prestressing. The widespread use of prestressed concrete was largely limited until the postwar period, when the economic use of materials was promoted to reduce cost.[314]

The first prestressed bridge in the United States was the Walnut Lane Bridge in Philadelphia, constructed in 1949. By the mid-1950s most states were constructing simple-span prestressed concrete beam bridges; however, the use of prestressed concrete beams for continuous spans was limited to only a few states.[315] During the mid-to-late 1950s, prestressed concrete quickly emerged as an important material for both Interstate and non-Interstate bridges across the country. Within Utah, the USRC used the material in 18 percent of the state's extant Interstate bridges and in approximately nine percent of the total extant bridge population.

Prestressed concrete is superficially similar to reinforced concrete in that both employ longitudinal steel elements within a beam of concrete. As bridge engineer T.Y. Lin explained: "the steel is pre-elongated so as to avoid excessive lengthening under service load, while the concrete is precompressed so as to prevent cracks under tensile stress. Thus an ideal combination of the two materials is achieved."[316] In addition to steel pre-tensioning, the major difference between reinforced concrete and prestressed concrete, according to Lin, is the latter's use of higher-strength materials, including high-tensile steel and high-strength concrete.

However, because of the use of high-strength materials, prestressed concrete has significant advantages over reinforced concrete. Prestressed concrete requires a smaller quantity of steel and concrete to carry the same loads as reinforced concrete and results in more efficient use of materials.[317] Like the reinforced concrete beam, a prestressed concrete beam is made deeper to provide greater span length. However, the prestressed beam can be proportioned to achieve longer spans without adding significant weight. This is done by increasing the compression force in the beam until the limit states of the concrete are achieved. As a result, prestressed concrete beams are shallower than their reinforced concrete counterparts, providing more clearance and enhancing their adaptability to grade-separation structures for the Interstate. Unlike reinforced

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[313] Hatt, "Current Research Work at Purdue," *Engineering News-Record*, 456-457; "Report of the Research and Extension Activities of the Engineering Schools and Departments for the Sessions of 1935-1936," *Engineering Bulletin Purdue University, Research Series Number 55, Engineering Experiment Station*, 17-18.

[314] Condit, *American Building: Materials and Techniques from the First Colonial Settlements to the Present*, 248-49.

[315] Based on the article, Florida is assumed to be one of the states that were using precast, prestressed concrete beams of continuous construction. The other states are not identified. W.E. Dean, "Continuous and Cantilever Bridges with Precast-Prestressed Concrete Beams," in *Proceedings Convention Committee Meeting Papers, New York, New York, October 5-7, 1965* (Washington, D.C.: American Association of State Highway Officials, General Offices, 1965), 267-268.

[316] Tung Y. Lin, *Design of Prestressed Concrete Structures* (New York: John Wiley & Sons, Inc., 1955), 9.

[317] Tung Y. Lin, *Design of Prestressed Concrete Structures*, 2d ed. (New York: John Wiley & Sons, 1963), 30-33.

concrete, prestressed concrete does not crack under working loads and deflections are reduced under dead and live loads. Because prestressed concrete beams typically do not crack, they are more durable and resistant to corrosion than reinforced concrete beams.[318] National research in the early 1960s suggested that, generally, prestressed concrete beams were economical and practical for bridges in the medium-span range from 40 to 100 feet, but were generally not cost-competitive for spans under 30 feet.[319]

Unlike reinforced concrete, prestressed beams require specialized tensioning or casting beds for their manufacture, meaning that they cannot be produced just anywhere by anyone or at the bridge site itself. The design and construction of the beds were technological achievements in their own right in the early years of prestressed usage, thus limiting prestressed to those precasters who made the investment in beds and could provide transportation of the beams to the site. On the other hand, precasting of prestressed concrete units allowed cost savings as large quantities of beams could be mass produced at factories and then delivered to construction sites, allowing for reuse of forms.[320] Historian Carl Condit describes the importance of precast beams: “The precasting and prestressing of girders for concrete bridges have brought their construction as close to the methods of mass production as the building arts have yet come.”[321] The USRC first mentioned prestressed concrete as a national development in its Twenty-third Biennial Report, July 1, 1953-June 30, 1954. According to the report, the USRC recognized that prestressed concrete would soon be applicable to design, but at that time they had not made any designs utilizing prestressed concrete beams. In the Twenty-fourth Biennial Report (1954-1955), the USRC issued a similar statement: no designs of prestressed concrete had been made.[322]

The USRC began addressing prestressed concrete structures in its 1960 *Standard Specifications for Road and Bridge Construction,* which superseded the 1952 specifications. Under this guidance, prestressing by either the pre-tensioning or post-tensioning method was left up to the contractor. The state specifications also included guidance on the inspection and transport of prestressed concrete beams. However, no indication was given as to whether the bridge design section followed standard shapes for prestressed concrete beams issued by the BPR, AASHO, and PCI.[323] A review of extant structures reveals that prestressed concrete was commonly used in Utah after 1959 for span lengths of less than 100 feet.

[318] Lin, *Design of Prestressed Concrete Structures*, 2d ed., 31-32.

[319] Norman L. Scott, "Suggestions for Reducing Costs in Prestressed Concrete Bridges," in *Highway Research Record Number 34: Bridge Design, Analysis, and Costs* (Washington, D.C.: Highway Research Board, 1963), 117.

[320] Lin, *Design of Prestressed Concrete Structures*, 31; Tung Y. Lin and Felix Kulka, "Fifty-Year Advancement in Concrete Bridge Construction," *Journal of the Construction Division, Proceedings of the American Society of Civil Engineers* 101, no. CO3 (September 1975): 494-495.

[321] Carl W. Condit, *American Building: Materials and Techniques from the First Colonial Settlements to the Present*, 2d ed. (Chicago: University of Chicago Press, 1982), 257.

[322] Twenty-third Biennial Report, 1953-1954, 29; Twenty-fourth Biennial Report, 1954-1955, 25.

[323] Utah State Road Commission, *Standard Specifications for Road and Bridge Construction*, (1960), 235-237, 240.

(c) Concrete rigid frame

Although nationally the rigid frame bridge type was somewhat infrequently used in other parts of the country, it was a popular recurring bridge type used in Utah from the 1920s through the postwar period. Overall this bridge type comprises 18 percent of bridges constructed through 1965 in Utah.

Introduced in 1923 by New York bridge designer Arthur G. Hayden, concrete rigid frame structures feature the superstructure and abutments as a continuous form, poured monolithically in one mold. Rigid frames were commonly used across the nation for highway and freeway bridge construction, particularly in parkways and grade separation structures, and can be ornamented with stone facing. Nationally, rigid frame designs were used primarily from the 1920s through the 1940s. While this design continued after World War II, their popularity decreased when the new prestressed concrete designs of the 1950s proved to be less labor intensive and more economical.[324]

A variation on the standard design is an open, or ribbed rigid frame, in which concrete is not present between the beams on the underside of the deck. Examples of this design variation are found in Utah and may have developed to reduce the amount of concrete and improve efficiencies. Although used for a variety of roadway types from the 1920s through the 1940s, rigid frame bridges were often chosen for grade-separation structures in urban locations following World War II and had spans ranging from 40 to 120 feet.[325] Within Utah's extant rigid frame population from the prewar period the span ranges were from 22 feet to 75 feet and from 11 to 82 feet in the postwar period. Since the deck and abutments act as a uniform system, these bridges carry the entire load with little help from a foundation, and were often used where logistics, setting, and/or cost prevented the construction of a substantial foundation.

Within Utah, concrete rigid frame structures were commonly used for short and medium span lengths and are most prevalent during the mid-1930s and extending through 1965.[326] Somewhat unusual when compared to national trends, rigid frame structures appear to have been built primarily over waterways in Utah rather than as grade-separation structures, and are located on a variety of roadway types including municipal, county, and state routes.

[324] Parsons Brinckerhoff and Engineering and Industrial Heritage, *A Context for Common Historic Bridge Types, NCHRP Project 25-25, Task 15* ([Washington, D.C.]: National Cooperative Highway Research Program, Transportation Research Board, 2005), 3.96-3.97.

[325] Parsons Brinckerhoff and Engineering and Industrial Heritage, 3.96.

[326] Fraser, 52.

Bridge 0D 517, Piute County at Mile Post 4.255, carrying SR-62 over East Fork Sevier River – an example of concrete rigid frame

Bridge 0D 496A, Davis County at Mile Post 6.179, carrying SR-126 over Weber-Davis Co. Canal – an example of concrete rigid frame

Bridge 0D 703, San Juan County at Mile Post 27.984, carrying SR-163 over Lime Creek – an example of concrete rigid frame

(d) Reinforced concrete and prestressed concrete beams (including slab, I-beam, T-beam, and box beam)

Overall this bridge type comprises approximately 31 percent of bridges constructed through 1965 in Utah making beams one of the most common bridge types.

The USRC used beams of reinforced and prestressed concrete including the slab, I-beam, T-beam, and box beam. Prestressed concrete beams grew in popularity in the late 1950s and early 1960s, and the USRC appears to have used a greater proportion of reinforced concrete beams then prestressed concrete beams. Approximately 21 percent of extant structures completed by the USRC are reinforced concrete beam or slab bridges, while approximately 10 percent are comprised of prestressed concrete beams

i. Concrete slabs

Reinforced concrete slabs, including both simple and continuous spans, comprise approximately eight percent of the extant bridge and culvert population. There are no prestressed concrete slab bridges in Utah.

A concrete slab structure includes a rigid horizontal monolithic slab that serves as both the deck and the structural member that carries stresses to the abutments and/or piers. By 1910 reinforced concrete slab structures were popular nationwide for shorter spans as the simplest and most economical of concrete bridge designs. The USRC released standards for concrete slabs beginning in 1913. The continuous slab introduced a single slab extending across several spans.[327]

[327] Parsons Brinckerhoff and Engineering and Industrial Heritage, 3.84-3.85.

Bridge 053011D, Washington County, carrying Middleton Drive over Middleton Wash in St. George – an example of concrete slab

Bridge 057010D, Weber County, carrying City Street over Willard Canal – an example of concrete slab

ii. Concrete multi-beam or girder

The basic form of the concrete girder, which is constructed in both reinforced and prestressed concrete, was developed by the first decade of the twentieth century. This bridge type comprises slightly more than six percent of bridges constructed through 1965 in Utah. Reinforced concrete comprises less than one percent and prestressed concrete account for nearly six percent of the total.

Concrete girders employ large horizontal members spanning from abutment to abutment or abutment to pier, carrying the load in a post-and-lintel system. Concrete girder bridges rose to be the most common type of bridge in the U.S. during the early-to-mid-twentieth century, and were common in Utah. Concrete girder bridges may be constructed using a variety of structural design concepts, including simple, continuous, and cantilever girder construction.[328] The USRC released standard plans for this bridge type beginning in 1913.

Developments in prestressed concrete during the subject period resulted in its application to concrete beams and girders. In the early 1950s most states were constructing simply supported precast, prestressed beams, while continuous construction was only used by a few states. Nationally, prestressed concrete girder bridges were largely economical and practical for medium spans from 40 to 100 feet, but were generally not cost competitive for spans below 30 feet.[329] With advances in technology, the use of precast, prestressed concrete became more common in the nation.

By 1960 prestressed concrete, with an emphasis on precast, pretensioned I-beams, was accepted as an effective material for increasing concrete beam span lengths up to a length of 130 feet.[330]

[328] Parsons Brinckerhoff and Engineering and Industrial Heritage, 3.93.

[329] Norman L. Scott, "Suggestions for Reducing Costs in Prestressed Concrete Bridges," in *Highway Research Record Number 34: Bridge Design, Analysis, and Costs* (Washington, D.C.: Highway Research Board, 1963), 117.

[330] Parsons Brinckerhoff and Engineering and Industrial Heritage, 3.100-101.

Bridge 0F 25, Cache County at Mile Post .855, carrying SR-61 over Bear River – an example of prestressed concrete multi-beam or girder

Bridge 0D 631A, Davis County at Mile Post .231, carrying SR-121 over I-15 – an example of concrete continuous multi-beam or girder

Bridge 029007F, Morgan County, carrying County Road over Union Pacific Railroad – an example of prestressed concrete multi-beam or girder

iii. Concrete T-beam

A T-beam structure features concrete "T-shaped" beams supporting an integral deck slab or a cast-in-place concrete deck that is used for the roadway surface. Steel rods are concentrated in the lower portion of the beams, and steel rods in the deck slab are laid perpendicular to the steel roads in the beams that are then tied together by U-shaped hangers. By doing this, the slab and beams become unified structural components, which increases the bridge's strength and allows for greater span lengths. With typical spans ranging from 30 to 50 feet, T-beams are often more economical than slabs for lengths exceeding 25 feet.[331]

Introduced in the 1910s, concrete T-beams were prevalent in the U.S. from the 1920s to the 1940s. Both simple spans and continuous spans of reinforced and prestressed concrete were built in Utah. The USRC released standard plans for this bridge type beginning in 1923.

Overall this bridge type comprises 15 percent of the bridge population. Reinforced concrete T-beams, including both simple and continuous designs, constitute approximately 12 percent of the extant bridge and culvert population, while prestressed concrete T-beams constitute three percent of extant structures.

A common variation on the prestressed T-beam is the double T-beam, which places two beams side by side, which is commonly found in T-beams in Utah.[332]

[331] Parsons Brinckerhoff and Engineering and Industrial Heritage, 3.88.

[332] Parsons Brinckerhoff and Engineering and Industrial Heritage, 3-88.

Bridge 0D 368, Cache County, carrying SR-101 over Little Bear River – an example of concrete T-beam

Bridge 019030D, Grand County, carrying County Road over Pinto Wash – an example of concrete T-beam

Bridge 0D 245, Garfield County at Mile Post 17.191 carrying SR-12 over Water Canyon Wash – an example of concrete T-beam

iv. Concrete box beam

The concrete box beam uses hollow boxes as its main supporting members. A box beam bridge is a fixed bridge consisting of various "box-shaped" sections used to support the deck. The first reinforced concrete box beams were built in the western U.S. in the late 1930s.[333] The box beam design was improved in the 1950s when designers began using prestressed steel wires rather than reinforcing steel bars to strengthen the box girders. AASHO first included specifications for prestressed concrete box beams in their 1957 publication.[334] These types were used nationally only in a limited extent prior to 1960, and standard shapes or forms were developed by AASHO and PCI in 1962.[335]

The USRC's use of the concrete box beam bridge form was infrequent. Three prestressed concrete box beams are extant in Utah, including Bridge 013002F in Duchesne County, built in 1965; Bridge 013001F in Duchesne County, built in 1965; and Bridge 035053F in Salt Lake County, built in 1964. However, only one reinforced concrete continuous box beam bridge (Bridge 1D 672) is extant. Built in 1961 as part of the Beck's Street Interchange in North Salt Lake City, this box beam structure carries a ramp from I-15 northbound to SR-89 northbound.

[333] California Division of Highways, *Manual of Bridge Design Practice*, 2d ed. ([Sacramento, Calif.]: State of California Highway Transportation Agency, Department of Public Works, Division of Highway, Bridge Department, 1963), 48.

[334] American Association of State Highway Officials, *Standard Specifications for Highway Bridges*, xxiii.

[335] *Safety Inspection of In-Service Bridges: Participant Notebook*, vol. 1-2([McLean, Va.]: U.S. Dept. of Transportation, Federal Highway Administration, National Highway Institute, 1992), 8.10.3.

Bridge 013001F, Duchesne County, carrying County Road at Sand Creek over Duchesne River – an example of prestressed concrete box beam

Bridge 013002F, Duchesne County, carrying County Road over Duchesne River – an example of prestressed concrete box beam

(e) Concrete deck arch

Concrete arch bridges came into widespread use following the introduction of Josef Melan and Fritz von Emperger's reinforcing systems in the late 1890s. In addition, Daniel Luten played an important role in the development of reinforced concrete arch construction in the United States. This bridge type was not frequently used in Utah, representing less than one percent of the total bridges constructed through 1965. Closed spandrel arches are best suited for short span lengths while open spandrel arches are used to achieve greater lengths.[336] The engineering department of USRC began experimenting with this bridge type in the late 1920s.

A variation within this bridge type is the catenary arch, shown below, which uses an elliptical arch instead of a traditional arch ring or barrel with a circular form. There is one known concrete arch with a centenary form in Utah, Bridge 0D 580, pictured below.

Bridge 4D 149, Utah County at Mile Post 2.669, carrying SR-164 over Spanish Fork River – an example of concrete deck arch

336 Parsons Brinckerhoff and Engineering and Industrial Heritage, 3.65-3.66.

Bridge 0D 580, Grand County at Mile Post 3.087, carrying SR-128 over Black Bill Wash – an example of concrete deck arch

Bridge 0D 582, Wayne County at Mile Post 72.161, carrying SR-24 over Sand Creek Wash – an example of concrete deck arch

(f) Concrete culvert

A nationally ubiquitous structure type, culverts were commonly constructed by the USRC throughout the twentieth century to meet the needs of shorter crossings, which constituted a large percentage of state bridge work.

Beginning in 1909 USRC provided standards on the use of concrete and metal in culvert design and specified the use of reinforced concrete for culvert structures with small spans.[337] The USRC released standard plans for this bridge type (see Table 2). 1913For the purposes of this study, bridges are defined as structures with spans greater than 20 feet. Culverts that have a span of 20 feet or greater are distinguished by the use of underfill to carry the roadway over the culvert structure and acts to carry much of the load. As a type, culverts generally do not display great innovation and became increasingly standardized and prefabricated.

Culverts make up 10 percent of the bridge population constructed through 1965 with 8 percent constructed in reinforced concrete. Reinforced concrete culverts were commonly used in Utah. The culverts greater than 20 feet that were included in this study, while only 10 percent of the total, represent a very common structure type. For example, in 2006 Utah had 2,800 bridges but more than 47,000 culverts.[338]

Culverts have two basic forms: box and pipe. They may have single or multiple spans, also called units. A concrete box culvert has four sides, some or all of which may be reinforced, and a square or rectangular opening. Concrete box culverts were built in the United States by the beginning of the twentieth century. Span lengths for reinforced box culverts ranged between 10 and 50 feet; shorter spans were typically unreinforced.[339]

Pipes have long been used as culverts with and without headwalls (walls located at the end of a culvert to divert flow, protect fill, and to serve as a retaining wall). In the twentieth century, concrete was a typical material. Pipes were prefabricated by manufacturers and shipped to construction sites.

The use of culverts grew significantly during the Interstate-building period following the war. At the time, the design of culverts was largely under the purview of manufacturers' trade associations; however, as culvert span lengths increased, AASHO and its successor, AASHTO, developed detailed specifications for metal and concrete culverts.

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[337] First Biennial Report, 1909-1910, 17-18.

[338] Timothy J. McGrath, et.al., "Culverts: Hidden Structures, Critical Infrastructure Elements," *Transportation Research Circular* E-C104 (September 2006), 109-120. Available at Transportation Research Board webpage http://onlinepubs.trb.org/onlinepubs/circulars/ec104.pdf .

[339] Charles H. Hoyt and William H. Burr, *Highway Bridges and Culverts*, *U.S. Department of Agriculture, Office of Public Roads - Bulletin No. 39* (Washington, D.C.: Government Printing Office, 1911), 15.

Bridge 011004E, Davis County, carrying 1000 East Street over Weber-Davis Canal – an example of concrete box culvert

Bridge E1150, Grand County at Mile Post 5, carrying SR-128 over Jackass Canyon Wash – an example of concrete box culvert

(2) Metal (iron and steel)

The choice of metal used, whether iron or steel, changed over time, as did the method by which metal members were connected. Wrought iron was the preferred metal until the 1890s when steel, with its minimal carbon content, became a popular bridge-building material, especially in truss bridge types.[340] There are no known wrought iron bridges in Utah. Steel has been used in bridge building since it replaced iron usage in bridge construction in the late nineteenth and early twentieth century at a time when the U.S. was in the forefront of the steel manufacturing industry.[341]

With the introduction of new manufacturing processes in the late nineteenth century, steel became available for structural use, including in bridges. Steel demonstrated strength and versatility, resisting the failure that had plagued its iron predecessors. Rolled steel beams were introduced in 1885, facilitating the material's use for short bridge spans. By 1895 steel overtook iron as the metal of choice in bridge design.[342] Steel bridges and culverts comprise approximately 30 percent of the extant bridges and culverts built through 1965, thus making steel the second-most widely used material in Utah next to reinforced concrete. Steel was also used in approximately 26 percent of the state's extant Interstate bridges and culverts.

Improvements to steel in the late 1930s through 1960 increased the material's strength and durability. As a result, span lengths were able to increase and new designs were used. After World War II, the increased use of welding over riveting, to connect steel members, allowed the design of more economical and lighter steel superstructures.[343]

Between 1946 and 1965, significant improvements in steel increased the strength and durability, allowing new bridge designs and longer spans. One of the major improvements to steel was the development of weldable low-alloy steel with a higher yield point, which raised the level at which steel incurred permanent deformation from stresses.[344] Steel companies, including Bethlehem Steel and U.S. Steel, introduced proprietary low-alloy steels of higher strength than mild steel during the study period. These high-strength products, including Bethlehem Steel's Mayari R and U.S. Steel's Cor-Ten B, allowed for a reduction in steel beam depths, reducing the amount of steel required for a comparable-strength beam. Additionally, Mayari R and Cor-Ten B were corrosion-resistant, high-tensile weldable steels that required no painting during a bridge's lifetime. Because of their high-strength and corrosion-resistant properties, these low-alloy

[340] Kemp, "The Introduction of Cast and Wrought Iron in Bridge Building," *IA: The Journal of the Society for Industrial Archeology*, 5-10.

[341] Parsons Brinckerhoff and Engineering and Industrial Heritage, 2-14.

[342] Mead & Hunt, "Indiana Bridges Historic Context Study, 1830s-1965," 70.

[343] Mead & Hunt, "Indiana Bridges Historic Context Study, 1830s-1965," 70.

[344] John Fisher et al, "Steel Bridges in the United States: Past, Present, and Future," *Transportation Research Circular* E-C104, (September 2006): 36.

products offered cost savings in materials and maintenance.[345] Structural low-alloy steel was addressed by AASHO standard specifications as early as 1949, with design requirements added for high-strength low-alloy steels in 1969.[346] Utah briefly addressed the use of high-strength low-alloy structural steel in its 1960 *Standard Specifications*, which stated that the steel should conform to the AASHO standard specifications.[347]

(a) Steel connection methods

The connection of steel structural members historically has been achieved by a variety of methods, including pins, rivets, welding, and bolts. The use of pin connections, introduced in truss bridges the 1840s, allowed for easier erection of bridges, much of which could be completed offsite. Pin connections feature removable "pins" or pegs inserted into holes that are aligned in adjoining structural members. Pin connections remained popular until the end of the nineteenth century when they were replaced by bolting and riveting. Bolting represents an intermediate method of connection that was used to erect truss bridges during the early twentieth century. Bolts replaced pins in smaller bridges and some through spans, but were quickly superseded by riveting. Factory-riveted connections emerged in the 1880s and field-riveted joints were introduced in the early 1900s. Riveted construction uses a gun-like mechanism to drive molten steel rivets into pre-drilled holes. The main structural members are riveted together using plates. Arc-welding slowly replaced riveting as an economical method for fastening metal structural members.[348]

Although each of these methods was well-established by the mid-1950s, they were at different stages of development and use. Except for cantilever and hinge connections, pinned connections were generally replaced by riveted connections. Riveting was increasingly replaced by welding in the mid-to-late-1950s. Bridge engineers employed bolts with rivets for many years but newer high-tensile bolts were gaining acceptance during the postwar period. While changes in connection methods between rivets and bolts impacted the design and construction of steel bridges at mid-century, the use of welding had a influence following World War II.

Arc-welding is a process by which steel parts are joined in their molten state, thus creating a metallurgical bond. Intense heat is provided to the joint by an electric arc. Before being applied to dynamically loaded structures, such as bridges, arc-welding was reserved for buildings and other statically loaded structures, including pipe work and shipping vessels during and after World

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[345] O.A. Kerensky, "Critical Survey of Bridge Design," *Engineering* (11 September 1959): 181-182; "Bridge Evolution: Many Factors at Work in Billion-A-Year Program," *Roads and Streets* 111, no. 1 (January 1968): 203.

[346] American Association of State Highway Officials, *Standard Specifications for Highway Bridges*, 5th ed. (1949), xix; American Association of State Highway Officials, *Standard Specifications for Highway Bridges*, 10th ed. (1969), xxviii.

[347] Utah State Road Commission, *Standard Specifications for Road and Bridge Construction*, (Salt Lake City: State Road Commission, 1960), 246.

[348] Mead & Hunt, "Indiana Bridges Historic Context Study, 1830s-1965," 70-71.

War I.[349] Arc-welding was first applied to the connection of metal bridges in the 1920s, and the process was readily accepted by the 1940s. The first arc-welded structure in the United States was built in 1927-1928 over Chicopee Falls in Massachusetts. This welded truss bridge completely eliminated rivets and used few bolts, and it employed one-third less the quantity of steel required by its riveted equivalent.[350] In the early 1930s all-welded highway bridges were constructed in France, Germany, and Poland, and by 1935 a small number of all-welded structures were constructed in Canada and the United States, with the states of Connecticut, California, and Kansas taking the lead.[351]

After World War II, state highway departments across the nation embraced arc-welding over riveting for fabricating built-up steel girders. Welding meant a reduction in the size and weight of structural members, allowing a lighter superstructure, reduced fabrication time and expense, and smoother surfaces with lower maintenance costs and less corrosion. Compared with riveting, welding typically resulted in a 15 to 20 percent savings in steel weight by making possible edge-to-edge joints without flange angles, splice plates, and rivets.[352]

The American Welding Society (AWS), a national professional organization, first published specifications for bridge-construction welding in 1936. As noted in their specifications, the USRC followed the AWS specifications for bridge-construction welding throughout the period.[353] A 1956 survey of 39 state highway bridge departments found that more than one-third were constructing an increased number of all-welded bridges and another third were using welding for bridge details such as coverplates, diaphragms, and shoes.[354]

During World War II, ship-builders advanced steel welding processes by introducing the automatic submerged arc-welding (SAW) process, which was later routinely applied to steel bridges. Automatic SAW became the most popular of the automatic arc-welding processes.[355] During the 1960s, numerous revisions were made to the AWS' specifications for welded highway

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[349] Nathan W. Morgan, *Welded Bridge Construction* (Washington, D.C.: U.S. Department of Commerce, Bureau of Public Roads, [1957]), 1; H. M. Priest, "Strength of Structural Welds," *Engineering News-Record* 107, (17 September 1931): 436.

[350] Gilbert D. Fish, "First Arc-Welded Railway Truss Bridge," *Engineering News-Record* 101, (26 July 1928): n.p.

[351] Mead & Hunt, "Indiana Bridges Historic Context Study, 1830s-1965," 71.

[352] A.L. Elliott, "How To Use High-Strength Steel Effectively," *Engineering News-Record* 164, (18 February 1960): 52-56.

[353] Utah State Road Commission, *Standard Specifications for Road and Bridge Construction*, (1952), 218; Utah State Road Commission, *Standard Specifications for Road and Bridge Construction,* (1960), 258-259.

[354] Robert G. Dyment, "Experience Aids Engineers in Welded Steel Bridge Design," *Consulting Engineer* (October 1956): 66.

[355] *Procedure Handbook of Arc Welding Design and Practice*, 11th ed. (Cleveland, Ohio: Lincoln Electric Company, 1957), 2.89; Ebbe Almqvist, *History of Industrial Gases* (New York: Kluwer Academic/Plenum Publishers, 2003), 373-374.

and railroad bridges. Provisions for the SAW process were included in the revised specifications in 1963, which detailed specifications for the filler metal and flux and optional testing to ensure the adequacy of welded joints.[356]

It is unknown when the USRC constructed its first all-welded highway bridge; however, welding specifications were provided in the USRC's 1952 and 1960 editions of *Standard Specifications for Road and Bridge Construction*. According to Fraser, the Weber River Bridge in Weber County, constructed in 1940 (nonextant), Bear River Bridge in Rich County (Bridge 0C 205, built in 1941), and Provo River Bridge in Utah County (Bridge 0C 199, 1941) represented the state's first use of large-scale welding on highway bridges.[357] Additionally, the award-winning White Canyon Bridge (Bridge 0C 491) was identified in the 1966 annual report as a "welded steel braced girder structure."[358] Within their specifications, the USRC required that all structural welding conform to the AWS specifications and that all work be completed by a certified operator. Additionally, in order to check the soundness of welds and to locate incomplete fusion or weld faults, following AWS specifications, the USRC routinely required radiographic inspections of bridge components during fabrication.[359]

Over the course of the twentieth century, traditional rivets and the riveting process for steel connections were largely replaced by bolts, particularly high-strength bolts. Use of high-strength bolts, manufactured from carbon steel and heat-treated for strength, was fairly new for structural steel connections in the 1950s. High-strength bolts were used on railroad bridges and were seen as a favorable option because they were cheaper to use in the field than rivets.[360] Although bolts had been used for structural connections on highway bridges for many decades, these previous connections, which were called "unfinished bolts," could not be tightened sufficiently to eliminate the possibility of slipping under shear loads.[361] The transition from rivets to high-strength bolts on highway bridges was slow nationwide and may have been prompted by the Research Council on Riveted & Bolted Structural Joints' (Research Council) formation in 1947. The Research Council was established "to advance the state of the art of civil engineering structural connections using threaded fasteners and rivets." In 1979 the council's name was changed to the Research Council

[356] La M. Grover, "Welding for Bridges," *Civil Engineering* 33, (December 1963): 60-63.

[357] Fraser, 56.

[358] Utah State Road Commission, *Standard Specifications for Road and Bridge Construction* (1952), 218; Utah State Road Commission, *Standard Specifications for Road and Bridge Construction* (1960), 258-259; *State of Utah Compiled Digest of Administrative Reports for Fiscal Year Ended June 30, 1966 to the Legislature, the Governor and for Other Essential Purposes* (Salt Lake City:[State of Utah], 1966), 112.

[359] Utah State Road Commission, *Standard Specifications for Road and Bridge Construction*, (1960), 258-259.

[360] T.R. Higgins and Mace H. Bell, "High-Strength Bolts - A New Structural Fastener," in *Proceedings of the Texas Structural Engineering Conference, March 21-22, 1952* (Austin, Tex.: The University of Texas, Department of Civil Engineering and Bureau of Engineering Research, [1952]), 43.

[361] Wayne Henneberger, "High Tensile Bolting of Highway Structures," *The Texas Engineer* 27, no. 7 (August 1957): 9.

on Structural Connections, partly "in recognition of the diminished importance of rivets as a fastener for structural connections."[362] In January 1951, soon after the council's formation, it approved and issued the "Specification for Assembly of Structural Joints Using High Tensile Bolts," allowing high-strength bolts to be substituted unit-for-unit for structural steel rivets of the same diameter.[363]

The Research Council was "largely responsible for high-strength bolting as we know it today," wrote W.H. Munse, professor of civil engineering at the University of Illinois, Urbana, in a 1967 *American Institute of Steel Construction (AISC) Engineering Journal* article on "High-Strength Bolting." Munse cited 10 advantages of the American Society for Testing and Materials (ASTM) A325 and A490 high-strength bolts and the bolting process; he found that high-strength bolts were considered superior to rivets and riveting in almost every way. High-strength bolts were stronger than rivets in both shear and tension. Unit for unit, the installed cost of bolts was as much as 20 percent less than rivets. A two-man bolting crew could install or fix more bolts in a given time than a four-man riveting crew could install rivets, and because bolts and bolting were more uniform, less inspection was necessary. Add to that the related issues of crew training (less training was needed with bolting crews), equipment (fewer tools and scaffolding were required for bolting), and reduced fire risk since riveting required on-site furnaces.[364] AASHO included standard specifications for high-strength bolts in their 1957 publication. Utah followed suit by addressing high-tensile bolts in their 1960 *Standard Specifications*. The USRC allowed that high tensile bolts "be substituted for rivets except as indicated by the plans or special provisions." Moreover, the USRC's specifications provided detailed information on the bolt, nut, and washer dimensions; the minimum tension and torque values; and installation requirements.[365] Available research found the earliest bridge plans specified the use of high-tensile bolts beginning in 1961, after its use had been standardized nationally and by the USRC, and does not represent the early application of this technology. Additionally, bridge plans only specified the use of high-tensile bolts. It is unknown if bridge contractors constructed the bridge following this specification. As such, bridges that specified the use of high-tensile bolts on plans is not considered a significant feature during the study period

(b) Steel beam and girder

Steel beam and girder bridges were commonly used in Utah and comprise approximately 23 percent of extant bridges and culverts. Although the terms "beam" and "girder" may sometimes be used interchangeably in engineering literature, for this context, a steel beam denotes a mill-

[362] "Research Council on Structural Connections, Background and Scope," Research Council on Structural Connections, http://www.boltcouncil.org/files/RCSCApplication.pdf (accessed 29 February 2008); "Minutes of [First] Meeting, Research Council on Riveted & Bolted Structural Joints, New York City, January 15, 1947," Research Council on Structural Connections, http://www.boltcouncil.org/files/OriginalMinutes.pdf (accessed 29 February 2008).

[363] T.R. Higgins and Mace H. Bell, "High-Strength Bolts - A New Structural Fastener," 28, 47.

[364] W.H. Munse, "High-Strength Bolting," *AISC Engineering Journal* (January 1967): 36.

[365] Utah State Road Commission, *Standard Specifications for Road and Bridge Construction*, (1960), 254-258.

rolled section and a girder denotes a built-up or fabricated member, such as a plate girder or box girder.

i. Multi-beam or girder bridges

Generally, steel beam bridges are built in a multi-beam design, with three or more parallel longitudinal beams of identical section and length uniformly spaced across the width of the bridge, with a concrete deck constructed on top of the beams. For spans over 90 feet, a multi-beam bridge is generally constructed with fabricated girders instead of rolled beams.

Steel girder bridges can be structurally classified as deck or through girders. Deck girders consist of a slab, or roadway surface, placed over two or more steel girders. A through girder is a structure in which the girder rises above the deck and appears as a parapet wall. Through girder bridges were prevalent in the early 1910s to 1930s. As roadways widened and concerns for vehicle collisions with parapets rose, deck girders became the norm after the 1930s. A plate girder is fabricated of built-up riveted, bolted, and/or welded steel plates with a deep web and top and bottom flanges. In a section, it resembles the letter "I." Fabricated plate girders have been used to span beyond the length of a standard steel I-beam. However, the longer the fabricated span, the deeper the girder was required to be. Standard plans were available nationally for plate girders by 1910 and the USRC released standards for plate girders in 1923. The type enjoyed popularity as an economical construction method in many states where fabricated steel was readily available. In 1960 the longest steel girders to ever be transported across the Rocky Mountains were used by the USRC for the construction of a bridge carrying I-15 north of Salt Lake City. The 116-foot steel plate girders were fabricated by Midwest Steel in Denver using steel plates from U.S. Steel Company's Geneva Works in Vineyard, Utah.[366] Since Interstate bridges are not evaluated as part of this study it is unknown if this bridge is extant.

In the 1920s and 1930s, steel I-beams were beginning to be used on highway bridges. The earliest known standard drawings of the rolled beam bridge were prepared by the BPR in 1917. By the 1930s, this type of bridge was employed more frequently throughout Utah. By the 1940s continuous beams with riveted splices were designed; however, economics and the rise in popularity of concrete prestressed bridges resulted in relatively fewer steel bridges erected.[367]

[366] "Utah Steel Returns to Highway Job," *Utah Highways and Byways*, (September 1960), Vol. 3, no. 12, 2.

[367] Parsons Brinckerhoff and Engineering and Industrial Heritage, 3-107.

Bridge 0C 298, Kane County at Mile Post .559, carrying US-89 over Blue Pool Wash – an example of a steel multi-beam or girder

Bridge 0C 276, Iron County at Mile Post 3.482, carrying SR-14 over Rocky Canyon Wash – an example of a steel multi-beam or girder

(3) Concrete and steel beams and girders – continuous and composite design

Beam and girder bridges may employ either simple or continuous design for multiple spans. Continuous designs with superstructures spanning uninterrupted over one or more intermediate supports were advantageous because they required less steel and concrete, produced less deflection, and avoided problematic joints over piers. Continuous spans were an engineering improvement over "simple spans" for certain site and roadway situations. In a simple span design, each span begins and ends on an abutment or pier. Continuous spans, which extend uninterrupted over one or more supports or piers, were used in highway construction beginning in the early 1940s because they produced less movement in the beam, avoided problematic joints over piers, and required less materials to build.[368] Only four percent of Utah's steel beam and girder bridges involved continuous design.

Continuous multi-beam bridges may also involve composite construction, which involves pouring a concrete deck on top of steel girders so the deck supplements the capacity of the top flange. The concrete slab is anchored to steel girders with shear connectors and, thus, concrete is used with steel for a fully composite design.[369] AASHO permitted composite bridge construction as early as 1944, including a section on composite beams in the 1944 and 1949 standard specifications.[370] However, composite design was not widely used until the 1950s and 1960s, when research on beam and shear connectors was conducted. As a result of research performed in the 1950s, the 1957 AASHO specifications section on composite beams was entirely rewritten.[371] The specifications were based on tests conducted at the University of Illinois, in which the capacities of channels, welded studs, and helical bars as shear connecters were assessed.[372] In 1961 AISC published specifications on composite design, and afterward the usage of composite structures increased considerably.[373]

The USRC first mentioned composite design as a national development in the Nineteenth Biennial Report (1945- 1946). During this biennium, the USRC prepared several composite

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[368] Parsons Brinckerhoff and Engineering and Industrial Heritage, 3-107, 3-143.

[369] Fisher et al. "Steel Bridges in the United States: Past, Present, and Future," *Transportation Research Circular*, 38; Kerensky, "Critical Survey of Bridge Design," *Engineering*, 180; Ben C. Gerwick, "Precast Segmental Construction for Long-Span Bridges," *Civil Engineering* 34, (January 1964): 44.

[370] American Association of State Highway Officials, *Standard Specifications for Highway Bridges*, 5th ed. (1949), xviii.

[371] American Association of State Highway Officials, *Standard Specifications for Highway Bridges*, 7th ed. (1957), xxiii.

[372] Eric L. Erickson and Neil Van Eenam, "Application and Development of AASHO Specifications to Bridge Design," *Journal of the Structural Division Proceedings of the American Society of Civil Engineers* ST4, (July 1957): 1320-16.

[373] Irwin A. Benjamin, "Composite Beams of Steel and Lightweight Concrete," *AISC Engineering Journal* (October 1965): 125.

designs for structures, but did not yet place the structures under contract.[374] Within the next two years, the USRC had built several structures featuring composite design, which resulted in "savings to the state."[375] However, it is unclear exactly which bridges employed composite design.

Bridge 0C 640, Uintah County at Mile Post .02, carrying SR-88 over Green River – an example of a steel continuous multi-beam or girder

(a) Steel arch

Used in the United States since the 1860s, the steel arch can be fixed, hinged, or tied and evolved from the iron "bowstring" truss patented in the 1840s. Some of Utah's most spectacular bridges of the 1930s and 1940s employed this design. Seven extant examples of this uncommon bridge type exist in Utah: four are deck arches and three are through arch design.

Tied steel arches are variations of a through arch, whereby the horizontal thrust of the arch is transferred to the horizontal tie. In the 1930s steel tied arches were generally used for short spans of 30 to 50 feet; however, more recent tied arches have been designed for spans of 180 to 900 feet.[376] Hinged steel arches are typically used for large spans and may feature one-, two-, or three-hinged bearings. Steel hinged arch bridges were used prior to the Civil War, but were employed to span great distances, typically over navigable waterways, in the 1930s when high strength allow steels were available.[377] Hinged arch bridges typically exhibit lengths that range

[374] Nineteenth Biennial Report, 1945-1946, 43.

[375] Twentieth Biennial Report, 1947-1948, 28.

[376] Parsons Brinckerhoff and Engineering and Industrial Heritage, 3.69.

[377] Parsons Brinckerhoff and Engineering and Industrial Heritage, 3-73.

from 500 to 1,675 feet.[378] During the 1960s and 1970s, the steel arch's popularity grew for significant crossings because of the arch's inherent aesthetic appeal and developments in economical erection methods for steel tied arches.[379]

The USRC's most frequently cited use of steel arches was the bridge over Cart Creek near Flaming Gorge Dam (Bridge 0C 372), built in 1962 by the USRC and the U.S. Bureau of Reclamation. The steel arch, with a suspended concrete deck and two 15-ton welded sections joined at the apex, was constructed by the U.S. Steel Corporation at a cost of $856,960. With a span of 550 feet, the Cart Creek Bridge was Utah's longest single-span highway bridge at the time. The AISC awarded the Cart Creek Bridge the first merit award in its "most beautiful bridge" competition of 1962.[380]

Additionally, the Colorado River Bridge (Bridge 0C 490), a continuous through arch carrying S.R. 95 over the Colorado River, and the Dirty Devil River Bridge (Bridge 0C 489), a steel deck arch carrying S.R. 95, were constructed in 1965 and identified as important structures in the USRC's annual report.[381] The AISC awarded the Colorado River Bridge (Bridge 0C 490) an award in the long-span category of its 1967 bridge competition.[382]

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[378] Parsons Brinckerhoff and Engineering and Industrial Heritage, 3.73.

[379] Fisher et al. "Steel Bridges in the United States: Past, Present, and Future," *Transportation Research Circular*, 38.

[380] *State of Utah Compiled Digest of Administrative Reports for Fiscal Year Ended June 30, 1963 to the Legislature, the Governor and for Other Essential Purposes* (Salt Lake City:[State of Utah], 1963), 97; "Cart Creek Bridge Construction Near Flaming Gorge Dam," *Utah Highways and Byways* (August-September 1962), vol. 5, nos. 11-12, 3; American Institute of Steel Construction, "Prize Bridge: 1960's Winners," http://www.aisc.org/contentNSBA.aspx?id=21368 (accessed 20 January 2010).

[381] *State of Utah Compiled Digest of Administrative Reports for Fiscal Year Ended June 30, 1966 to the Legislature, the Governor and for Other Essential Purposes*, 112.

[382] American Institute of Steel Construction, "Prize Bridge: 1960's Winners," http://www.aisc.org/contentNSBA.aspx?id=21368 (accessed 20 January 2010).

Bridge 0C 293, Washington County at Mile Post 19.704, carrying SR-18 over Santa Clara River – an example of a steel arch

Bridge 0C 372, Daggett County at Mile 392.605, carrying SR-191 over Flaming Gorge Reservoir – an example of a steel arch

(b) Steel truss

Truss bridges became common in the U.S. in the mid-nineteenth century, replacing stone arch or timber beam structures. There are three basic arrangements of trusses—pony, through, and deck—and a wide variety of truss configuration. A truss bridge has a superstructure that features two parallel trusses, which use diagonal and vertical members to support deck loads. Diagonal and vertical members are joined with plates and fasteners (pins, rivets or bolts) to create several rigid triangular shapes which are located between parallel bottom and top chords. This configuration can create long spans of relatively lightweight units.

The choice of truss configuration (e.g. Pratt, Parker, or Warren) and type (e.g. deck, through, cantilever) primarily depended upon the required span length. Continuous and cantilevered designs were typically employed for greater span and structure lengths. Truss configurations generally developed in the mid-nineteenth century. For example, the Pratt truss, developed by Thomas and Caleb Pratt in 1844, was typically employed for spans ranging from 25 to 250 feet. The Warren truss, the most common truss type used in the twentieth century, patented in 1848, could span 50 to 400 feet.[383]

Bridge 017044C, Garfield County, one-half mile west of Antimony carrying County Road over East Fork Sevier River – an example of a Pratt through pony truss

[383] Parsons Brinckerhoff and Engineering and Industrial Heritage, 3-25, 3-29.

Bridge 005034C, Cache County, North of Trenton carrying County Road over the Bear River – an example of a Pratt through overhead truss

Steel and timber truss bridges were widely used in Utah from the 1910s through the 1920s, dropping off notably in the 1930s and decreasing dramatically after the war. In the 1910s and 1920s steel trusses tended to be used more frequently in the more populous areas with good railroad connection, since most steel truss superstructures had to be fabricated out of state and then shipped to the bridge site in Utah. This factor limited their use in rural areas.

It was not until the early twentieth century that Utah construction and engineering firms were established that specialized in bridge building. The Andrews Bridge Company, the first Utah truss fabrication firm, was established in 1898 and operated until 1900. In 1901 Dederichs and Burke, another early firm, opened as a local agent of the Gates Iron Works of Chicago and the Minneapolis Steel and Machinery Company, bridge fabricators in which bridges were ordered and the assembled on site. Burke remained in business until 1944 and was responsible for fabricating a number of steel truss bridges in Utah and Wyoming.[384] Out-of-state firms continued to account for a substantial amount of Utah bridge building the first two decades of the twentieth century.

By 1913 the Engineering Department of the USRC had a standard design for the Warren pony trusses, the state's most common truss configuration.[385] Because "there are only a very few places in the State where the State Road crosses a stream requiring a span greater than 100 feet" the Engineering Department placed a priority on standard bridge designs for spans up to

[384] Fraser, 8-9.

[385] Fraser, 22. An example of the standard design Warren pony truss is illustrated in the Third Biennial Report of the USRC 1913-1914.

and including 100 feet. In addition to the Warren pony truss design, plans were prepared for the timber Howe truss bridge. By the 1915-1916 biennium the USRC reported that standardized bridge plans were being widely employed for bridge superstructures.[386]

A review of USRC biennial reports shows the most common truss construction consisted of the Warren pony truss type for short spans (100 feet and under). The Price River Bridge at Helper in Carbon County (nonextant), Price River Bridge at Mound in Emery County (nonextant) and the Adamsonville Bridge in Beaver County (001003C, pictured in Section 4) are examples of these early standard plan truss bridges by the USRC identified by Fraser. The Adamsonville Bridge is still extant.

The USRC Engineering Department also instituted a category of "special designs" in cases that demanded individual design and engineering.[387] These "special design" bridges were generally longer span bridges that required a span greater than 100 feet. One, or perhaps two, of these type of bridges might be designed and constructed during one USRC biennium. One of the state's longest truss spans was the Jensen Bridge (Uintah County Bridge 0C126 [nonextant]), erected in 1933 and fabricated by the Midland Bridge Company. The bridge consisted of three Parker through trusses and measured 525 feet in length.[388]

The state has one extant truss bridge from the postwar period and it features an uncommon configuration: a Bailey truss.[389] The Bailey truss bridge was a modular, prefabricated bridge type developed during World War II for war field installations to carry military vehicles. After the war, surplus Bailey trusses were sold and erected in the United States, often for temporary or emergency crossings. As a prefabricated bridge type with interchangeable steel components, a Bailey truss could be assembled in seven different configurations. The number of successive panels used on each side of the bridge determined the structural strength of the span.[390] According to the *Twenty-third Annual Report*, *July 1, 1953-June 30, 1954,*the USRC erected Bailey bridges during the early 1950s for emergency purposes, with the expectation of replacement. Bridges listed in the 1954 biennial report included the 130-foot truss (nonextant) over the Muddy River in Wayne County, the 100-foot bridge over the Fremont River (Bridge 055007C) in Wayne County, and the 100-foot truss over Butler Wash in San Juan County

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[386] Third Biennial Report, 1915-1916, 30.

[387] First Biennial Report, 1909-1910, 17

[388] Fraser, 18.

[389] Utah State Road Commission, "Structures 20 foot span or over on State Road System, March 1, 1957," ([Salt Lake City]: N.P., [1957]), n.p., Available at University of Utah, Marriot Library Special Collections, Salt Lake City; Utah Department of Transportation; *Bridge Inventory Database*, 2009.

[390] JRP Historical Consulting Services, *Historic Context Statement: Roadway Bridges of California: 1936 to 1959*, (Prepared for State of California Department of Transportation, January 2003), 42-43.

(nonextant).[391] Within three years, another Bailey truss (nonextant) was located on a Utah roadway in Kane County.[392]

Bridge 055007C, Wayne County, carrying County Road over Fremont River – an example of a steel truss

(c) Steel rigid frame

The steel rigid frame bridge type was developed at the same time as the concrete rigid frame; however, the steel version is an uncommon type both nationally and in Utah. The choice to use steel for a rigid frame bridge was largely determined by economics or aesthetics. Steel rigid frame bridges were built between the early 1920s and 1950s.[393] Used for spans of 50 to 200 feet, steel rigid frame structures feature inclined frame sides (legs) that are integral with the horizontal girders and contribute to the load-bearing capacity of the bridge.[394]

There is one extant steel rigid frame bridge in the state – the White Canyon Bridge (Bridge 0C 491) carrying S.R. 95 over White Canyon in San Juan County. Built in 1965 with a maximum span of 87.9 feet, the bridge received the AISC's 1966 prize award in the short span category.[395]

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[391] Twenty-third Biennial Report, 1953-1954, 28.

[392] Utah State Road Commission, "Structures 20 foot span or over on State Road System, March 1, 1957," District 3, page 5, District 4, pages 4, 7.

[393] Parsons Brinckerhoff and Engineering and Industrial Heritage, 3-113.

[394] Parsons Brinckerhoff and Engineering and Industrial Heritage, 3.113.

[395] *State of Utah Compiled Digest of Administrative Reports for Fiscal Year Ended June 30, 1966 to the Legislature, the Governor and for Other Essential Purposes*, 112-113; American Institute of Steel Construction, "Prize Bridge: 1960's Winners," http://www.aisc.org/contentNSBA.aspx?id=21368 (accessed 20 January 2010).

Bridge 0C 491, San Juan County at Mile Post 53.607, carrying SR-95 over White Canyon – an example of a steel rigid frame

(d) Steel culvert

A nationally ubiquitous structure type, culverts were commonly constructed by the USRC throughout the twentieth century to meet the needs of shorter crossings, which constituted a large percentage of state bridge work.

Beginning in 1909 USRC provided standards on the use of metal in culvert design.[396] The USRC released standard plans for this bridge type beginning in 1913 (see Table 2). For the purposes of this study, bridges are defined as structures with spans greater than 20 feet. Culverts that have a span of 20 feet or greater are distinguished by the use of underfill to carry the roadway over the culvert structure and acts to carry much of the load. As a type, culverts generally do not display great innovation and became increasingly standardized and prefabricated.

Culverts make up 10 percent of the bridge population constructed through 1965, with two percent constructed in steel. Steel culverts were commonly used In Utah. While only culverts greater than 20 feet, which represent 10 percent of the total bridges constructed through 1965, are included in this study as a structure type, culverts of any length are very prevalent. In 2006 Utah had 2,800 bridges and more than 47,000 culverts.[397]

A review of the USRC's biennial reports finds that steel culverts were more commonly used in the populous Wasatch Front counties in the 1910s and 1920s, and the use of corrugated steel pipes

[396] First Biennial Report, 1909-1910, 17-18.

[397] McGrath, 109-120.

came to predominate throughout the state beginning in the 1930s. Steel culverts have two basic forms: box and pipe.

A steel box culvert has a flat or slightly arched top and vertical sides. Its shape is well-suited for locations where there is minimal elevation differential between the road and streambed. Box culverts are manufactured from standard structural steel that is reinforced with equally spaced ribs. They are available in spans up to 21 feet, though larger structures can be designed by combining multiple spans.[398]

Pipes have long been used as culverts with and without headwalls (walls located at the end of a culvert to divert flow, protect fill, and to serve as a retaining wall). In the twentieth century, corrugated metal, steel, and concrete were typical materials. Pipes were prefabricated by manufacturers and shipped to construction sites. An example of prefabricated metal pipe culverts is the "Nu-Arch Culvert," which were introduced by Granite City Steel Company of Granite City, Illinois, in 1940. These culverts featured a half-circle section of corrugated metal pipe that was both economical and efficient to erect.[399]

Bridge 0V 651, San Juan County at Mile Post 12.503, carrying SR-163 over Halgaitah Wash – an example of a steel pipe culvert

[398] *Handbook of Steel Drainage & Highway Construction Products*, 3rd ed. (Washington, D.C.: American Iron and Steel Institute, 1983), 13.

[399] "Advertisement for Granite City Steel Company Nu Arch Culverts," *Engineering News-Record* 125, (10 October 1940): n.p.

Bridge 0V 624, Beaver County at Mile Post 42.458, carrying Sr-21 over Corral Canyon Wash – an example of a steel culvert

Bridge 0V1419, Garfield County, carrying SR-12 over Campbell Creek – an example of a pipe steel culvert with corrugated steel

(4) Timber

Timber, like stone, is one of the oldest bridge-building materials. Timber was used extensively for many bridge types, including culverts, trusses, beams, and slabs in nineteenth and early twentieth century United States. There are no extant culverts or timber truss bridges, but timber beams and slabs were constructed through 1965, comprising a little more than six percent of the extant bridge population.

Timber bridges were most frequently used in remote counties where the transport of concrete and steel represented a substantial cost. While the use of timber bridges declined steadily through the 1930s, they were commonly used in Utah. The traditional timber bridge had a limited life expectancy compared to other materials. An exposed wood bridge may be expected to last 10 to 20 years if not damaged by fire or flood.[400] However, in areas with dry desert climates and alkaline environmental conditions, such as in Utah, timber bridges may last longer. The context (Section 3) found that USRC determined that timber bridges required less maintenance and upkeep than steel bridges, which did not stand up well to the alkaline environment.

Timber generally fell out of favor for highway bridge construction as transportation loads increased and new materials and fabricating methods became more economical. Timber bridges were used in Utah for low volume routes, primarily on county and local roads.

Twentieth-century innovations improved the functionality of the material and design and included creosote-treated timber and glue-laminated timber, known as Gluelam. A light treatment of creosote could approximately double the life of an untreated timber bridge by preventing decay and termite destruction. Gluelam structures were experimented with nationally in the 1940s and used routinely for stringer bridges during the subject period.[401] AASHO standard specifications included a section on creosote and preservation treatments for timber structures in 1949, and the section was revised in 1957.[402]

(a) Timber multi-beam beam or girder

Timber multi-beam beam or girder (also known as timber stringers) bridges are comprised of a timber plank deck supported by heavy square or rectangular, solid-sawn wood beams. Timber stringer bridges were typically utilized for short spans of 10 to 30 feet. As one of the earliest bridge types in the United States, timber stringer structures persisted through the subject period as a result of the structure's simplicity and ready availability of material.[403] Ninety percent of extant timber structures built in Utah are classified as timber stringers.

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[400] Charles Felkner, "Parke County Covered Bridges Thematic Resource," National Register of Historic Places, National Park Service, 1978.

[401] Sheila R. Duwadi and Michael A. Ritter, "Timber Bridges in the United States," *Public Roads* 60, no. 3 (winter 1997): 5.

[402] American Association of State Highway Officials, *Standard Specifications for Highway Bridges*, 5th ed. (1949), xi; American Association of State Highway Officials, *Standard Specifications for Highway Bridges*, 7th ed. (1957), xxiii.

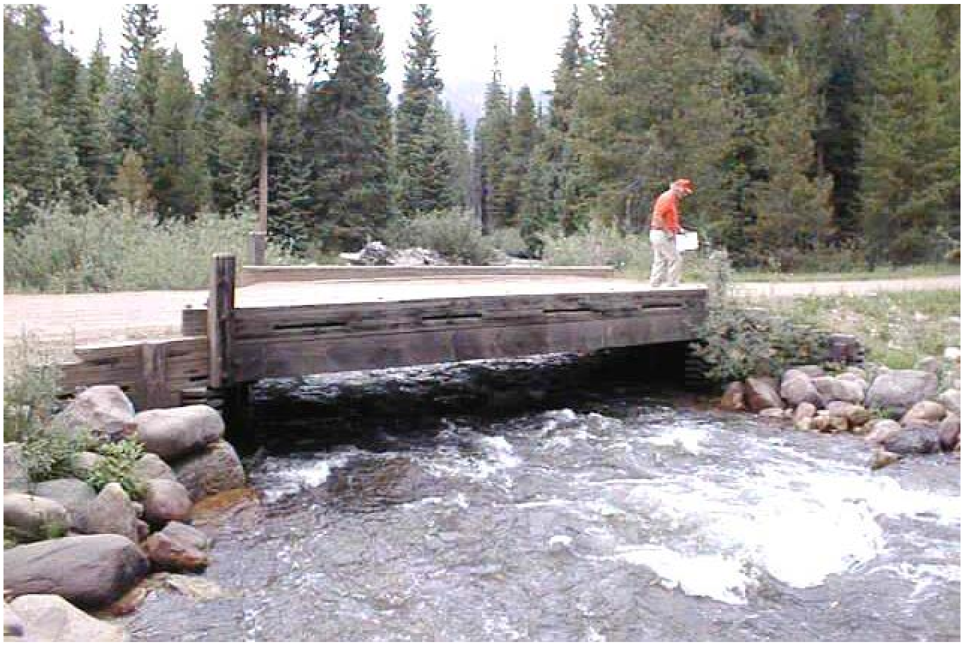
[403] Parsons Brinckerhoff and Engineering and Industrial Heritage, 3.81.

Bridge 047020A, Uintah County, carrying 1000 South Street over Steinaker Canal – an example of a timber stringer

(b) Timber slab

Timber slab bridges are comprised of timber panels, often glued together end on end, and arranged in a longitudinal orientation, parallel to the flow of traffic. The timber panels rest on transverse members or cross beams, which assist in distributing the load between timber panels. Ten percent of extant timber structures built in Utah are classified as timber slabs.

Bridge 043010A, Summit County, carrying County Road over Weber River – an example of a timber slab



Bridge 043011A, Summit County, carrying County Road over Middle Fork, Weber River – an example of a timber slab

(5) Tunnels

While not a bridge or culvert type, two extant tunnels are included in the inventory. Tunnels represent an uncommon structure type both in the U.S. and in Utah. The two examples (0V 55 and 0V 56) consist of single bores through solid rock in Garfield County on State Route 12 constructed in 1941.

D. Aesthetics in bridge design

Whether or not a bridge design exhibits intentional aesthetic treatment can be a subjective determination, especially because aesthetic ideals change over time.

In Utah the application of standard state bridge design began in 1913 and 1923 for many structures over 100 feet. One of the results of standardization was a trend seen nationally of bridge design becoming less dependent on local preferences and practitioners. Consideration for aesthetics also waned as production of bridge designs that could be erected quickly and inexpensively became increasingly important to meet the burgeoning demand for transportation routes, especially after World War II. This trend is also true in Utah. However, at the same time, there were still bridges constructed by local craftsman, bridge builders, and private companies by local jurisdictions and "special design" (greater than 100 feet) state bridge projects that may have resulted in a greater variety of bridge features, including ornamentation.

Certain bridge types and materials lend themselves more readily to aesthetic treatment. In particular, arch bridges, in both stone and concrete, are frequently embellished with applied ornamentation and/or architectural treatment of the materials. However, as Historian Carl Condit notes, by 1910 there was generally a movement away from massive construction towards "the flattened parabolic curves of narrow ribs, the slender spandrel posts, and the minimal piers that scientific reinforcing was to make possible."[404] World War I coupled with the incorporation of bridge building into state and federal government agencies and the development of standardized bridge plans brought changes to the aesthetics of bridge design. For most common bridge types, particularly slabs, beam, and girder types, aesthetic principles were rarely applied and when they were incorporated typically appeared in railings.

In Utah, little attention was given to aesthetic considerations in bridge construction. Significantly financially constrained, the USRC and counties were primarily focused on utility. To some degree this began to change in the late 1920s when the USRC began to acknowledge aesthetics as a consideration in bridge design. In the 1920s the USRC noted that in urban areas an effort was made to coordinate its bridge structures aesthetically with their context in Salt Lake City and Ogden.[405] Many of the bridge types favored by the USRC, such as concrete slabs and concrete rigid frames did not easily lend themselves to aesthetic embellishment. Ornamental features specific to each bridge type are described further in Table 1, Volume II.

The remainder of this section describes the aesthetic trends that were found in bridges in Utah, which include the City Beautiful (Bridge 0D 540 in Cache County, 1918 with rehabilitation work completed in 1951 and 2003), Art Deco and Streamline Moderne, and Rustic styles found in several grade-separation bridges, and postwar aesthetics.

The 1893 World's Columbian Exposition was a decisive moment in the application of architectural aesthetic concerns to concrete bridge design. The elaboration of the Exposition's ideals by the City Beautiful Movement ensured the use of Neoclassical design elements in structural design. Proponents of the movement argued for monumental structures that exhibited durability, strength, fitness, grace, and beauty to reinforce civic values. The aesthetic as it applied to bridge design often resulted in the presence of Neoclassical balustrades, arch rings with keystone, incised panels and light standards.

Beginning in the New Deal era, federal government programs, such as the WPA and CCC, were active participants in bridge design and construction. Public works projects may exhibit aesthetic treatment that reflected architectural styles such as Rustic, Art Deco, and Streamline Moderne.

The Art Deco style, which enjoyed its peak of popularity between 1920 and 1930, was characterized by the use of ornate geometric motifs to express contemporary trends of industrialization and modernization. Moderne style, or Streamline Moderne, was a more restrained version of the Art Deco style and was popular from 1930 until World War II. Moderne designs featured smooth surfaces and curved corners. Several grade-separation bridges reflect elements of the Art Deco and Streamline Moderne.

[404] Condit, *American Building: Materials and Techniques from the First Colonial Settlements to the Present*, 251.

[405] Fraser, 42.

Bridge 0C 149, Utah County, carrying railroad over U.S. 89 – an example bridge constructed in the Art Deco/Streamline Moderne aesthetic

The Rustic style was also employed for bridge design, typically on stone or stone-faced concrete arches built by Great Depression era funding or labor. In the 1930s, no doubt under the influence of the federal work relief programs, the USRC acknowledged that bridge design could harmonize with their surroundings and also the general character of the traffic.[406] Bridge 0D 807, a concrete arch bridge in Salt Lake County (1935), displays features of the Rustic style with the application of stone veneer.

Bridge 0D 807, Salt Lake County, carrying SR-209 over Little Cottonwood Creek – an example bridge constructed in the Rustic aesthetic

[406] Twelfth Biennial Report, 1930, 31.

In the postwar period, aesthetics in bridge design was largely achieved through the refinement and proportion of structural members rather than through the application of ornamentation and/or architectural treatment of materials. David P. Billington, professor of engineering at Princeton and author of notable works on bridge history, has described the criteria for structural art as "minimum materials, minimum cost, and maximum aesthetic expression."[407] Bridges of the period generally follow this formula, such that material technology, which resulted in innovative steel and concrete structural systems that made unprecedented span lengths possible, and economics go hand-in-hand with aesthetic potential.

For most bridge types from this era, aesthetics is most evidenced in the bridge's proportions, symmetry, harmony with its location, and occasionally in railing standards. Generally, most bridges feature simple and clean lines, with little or no applied ornamentation. At the beginning of the postwar period, the USRC commented that although past funding constraints resulted in structures chosen primarily for their low cost and simplicity of construction, recent thought held that "limited expenditure on architectural treatments is well justified; such treatment should, wherever possible, be restricted to simplicity of line and surfaces skillfully proportioned to enhance the overall appearance without undue increase in construction cost."[408] This sentiment was repeated in the biennial and annual reports throughout the subject period.

Exemplifying the attention given to the refinement and proportions of structural members, Stanley Grossman, a consulting engineer in Oklahoma, argued in a national engineering journal in 1965 that in addition to reducing material costs, wide beam spacing in highway bridges presented "a clean, light, and uncluttered appearance for short span bridges by reducing the number of stringers and eliminating the need for cap beams on the piers."[409] Similarly, although finding fault with grade-separation structures of the 1960s, Joseph Barnett of the BPR was encouraged by a recent trend toward minimizing piers and columns through the use of greater deck depth, which he thought resulted in improved appearance. Barnett called for bridge engineers to be attentive to proportion and shadow lines.[410]

Nationally, engineers advocated horizontally curved girder bridges in urban interchange situations for their economy, efficiency, and aesthetically pleasing appearance.[411] Additionally, a general Interstate "aesthetic" emerged, whether intentional or not, which included the seamless incorporation of bridges and culverts into the endless roadway so that road structures would be invisible to the motorist and not a visual distraction. As much a safety consideration as an aesthetic one, this design was in keeping with

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[407] David P. Billington, "Bridges and the New Art of Structural Engineering," in *Bridge Aesthetics Around the World* (Washington, D.C.: Transportation Research Board, National Research Council, 1991), 72.

[408] Nineteenth Biennial Report, 1945-1946, 44.

[409] Stanley Grossman, "Short Span Highway Bridges with Wide Stringer Spacing and a Two-way Reinforced Concrete Deck," *AISC Engineering Journal* (April 1965): 55.

[410] Joseph Barnett, "Road Design: Some Modern Aspects," *Traffic Engineering* 34, no. 4 (January 1964): 22.

[411] W.M. Thatcher, "Horizontally Curved Steel Girders-Fabrication and Design," *AISC Engineering Journal*, 107; James W. Gillespie, "Analysis of Horizontally Curved Bridges," *AISC Engineering Journal*, 137-138; Charles Culver, Darryl Brogan, and David Bedner, "Analysis of Curved Girder Bridges," *AISC Engineering Journal* (January 1970), 10.

the elimination of intersections and stoplights and the incorporation of gradual entrance and exit ramps. In this sense, the Interstate or freeway design approach of seamlessness was the opposite of what had prevailed during the nineteenth and most of the twentieth century. In earlier designs, any aesthetic treatment was designed to call attention to the structure in order to make it stand out from its surroundings through the artistic or ornamental treatment of structural elements.[412]

Despite these allusions to aesthetics, in Utah and the nation, bridge design publications and standards did not focus on the subject. The USRC's primary focus, like most highway departments, was on the construction of economical and functional structures, while a lesser priority was placed on the incorporation of aesthetics. High labor costs, the need to build many bridges quickly, and improved methods of mass production contributed to the secondary consideration of bridge aesthetics. Additionally, during this period, the appearance of ornament on a publicly-funded structure could raise questions about the appropriate use of taxpayer dollars. By the 1950s public attitude had changed and ornament equaled excess spending. In its own way, however, the popular response to intentional ornament was very compatible with the "less is more" philosophy of professional architects and the stripped-down functionality of engineers during the period.

Whether officially documented or not, the USRC did identify a "policy towards preserving the aesthetic values of highways" in addition to bridges in their *Annual Report for Fiscal Year Ended June 30, 1963*. However, the report did not identify the specific tenets guiding this policy. In 1963 the USRC's efforts to construct and beautify S.R. 279 between Moab and the Potash Plant in Grand County were recognized in a national contest sponsored by *Parade Magazine.*[413]

Five bridges in Utah that display postwar aesthetics were awarded prizes in the AISC's annual bridge contest. Award-winning bridges included:[414]

- Colorado River Bridge (nonextant) carrying U.S. 191 over the Colorado River in Moab. This steel bridge was designed by Woodruff & Sampson and fabricated by the American Bridge Division of U.S. Steel Corporation. It received an honorable mention in the 1955 competition.[415]

- Cart Creek Bridge (Bridge 0C 372) carrying S.R. 191 over Cart Creek near Flaming Gorge Dam in Daggett County. This steel arch bridge was designed by the USRC and fabricated by the

[412] Lichtenstein Consulting Engineers, *The Third Ohio Historic Bridge Inventory, Evaluation, and Management Plan for Bridges Built 1951-1960 and the Development of Ohio's Interstate Highway System* (Ohio Department of Transportation, 2004), 26-27; Phil Patton, *Open Road* (New York, 1986), 133-135.

[413] *State of Utah, Compiled Digest of Administrative Reports for Fiscal Year Ended June 30, 1963 to the Legislature, the Governor and for Other Essential Purposes*, (Salt Lake City: State of Utah, 1963), 99.

[414] American Institute of Steel Construction, "Prize Bridge Competition: Previous Winners," http://www.aisc.org/contentNSBA.aspx?id=20760 (accessed 20 January 2010).

[415] See also "Bridge Design Division – Century and a Half of Service," *Utah Highways and Byways* 1, no. 8 (May 1958): 2. Research did not identify where the firm of Woodruff & Sampson was headquartered.

American Bridge Division of U.S. Steel Corporation. It received a first merit award in the "long span with main spans over 400 feet" category of the 1962 competition.[416]

- Eagle Canyon Arch Bridge (Bridge 2C 495) carrying I-70 over Eagle Canyon in Emery County. Built in 1965, this steel arch bridge was designed by the USRC, fabricated by Western Steel Company, and erected by Strong and Company. It received an award in the "medium span, high clearance" category in the 1966 competition.[417]

- White Canyon Bridge (Bridge 0C 491) carrying S.R. 95 over White Canyon in San Juan County. Built in 1965, this continuous steel rigid frame bridge was designed by the USRC, fabricated by Titan Steel Corporation, and erected by S.S. Mullen, Inc. It won an award in the "short span" category in the 1966 competition.[418]

- Colorado River Arch Bridge (Bridge 0C 490) carrying S.R. 95 over the Colorado River at the Garfield-San Juan County Line. Built in 1965, this continuous steel arch bridge was designed by the USRC, fabricated by Western Steel Company, and erected by W.W. Clyde and Company. It received an award in the "long span" category of the 1967 competition.[419]

[416] See also *State of Utah Compiled Digest of Administrative Reports for Fiscal Year Ended June 30, 1963 to the Legislature, the Governor and for Other Essential Purposes* (Salt Lake City:[State of Utah], 1963), 97; "Cart Creek Bridge Construction Near Flaming Gorge Dam," *Utah Highways and Byways* 5, nos. 11-12 (August-September 1962): 3.

[417] See also *State of Utah Compiled Digest of Administrative Reports for Fiscal Year Ended June 30, 1966 to the Legislature, the Governor and for Other Essential Purposes*, 112-113.

[418] See also *State of Utah Compiled Digest of Administrative Reports for Fiscal Year Ended June 30, 1966 to the Legislature, the Governor and for Other Essential Purposes*, 112-113.

[419] See also *State of Utah Compiled Digest of Administrative Reports for Fiscal Year Ended June 30, 1966 to the Legislature, the Governor and for Other Essential Purposes*, 112-113.

Bibliography

"A Five Million Dollar Road Gets a Four Million Dollar Link," *Utah Highways and Byways* 2 (March 1959): 5.

"Access Roads to Dams Get Attention of State Road Commission." *Utah Highway Progress* 2, no. 6 (22 June 1959): 1-2.

"Advertisement for Granite City Steel Company Nu Arch Culverts." *Engineering News-Record* 125. (10 October 1940): n.p.

Alexander, Thomas. *Utah the Right Place.* Salt Lake City: Gibbs Smith Publishers, 2007.

Almqvist, Ebbe. *History of Industrial Gases.* New York: Kluwer Academic/Plenum Publishers, 2003.

American Association of State Highway Officials. *A Policy on Arterial Highways in Urban Areas.* Washington, D. C.: American Association of State Highway Officials, 1957.

-----. *A Policy on Design Standards: 1-Interstate System, 2-Primary System, 3-Secondary and Feeder Roads.* Washington, D.C.: American Association of State Highway Officials, 1956.

-----. *A Policy on Design Standards: Interstate System.* Washington, D.C.: American Association of State Highway Officials, 1959.

-----. *A Policy on Geometric Design of Rural Highways.* Washington, D.C.: American Association of State Highway Officials, 1954.

-----. *A Policy on Grade Separations for Intersecting Highways.* Washington, D.C.: American Association of State Highway Officials, 1944.

-----. "Geometric Design Standards for the National System Interstate and Defense Highways." *American Highways* (October 1961): n.p.

-----. *Policies on Geometric Highway Design.* Washington, D.C.: American Association of State Highway Officials, 1945 (reprinted 1950).

-----. *Standard Specifications for Highway Bridges*. 5th ed. Washington, D.C.: American Association of State Highway Officials, 1949.

-----. *Standard Specifications for Highway Bridges*. 7th ed. Washington, D.C.: American Association of State Highway Officials, 1957

-----. *Standard Specifications for Highway Bridges*. 8th ed. Washington, D.C.: American Association of State Highway Officials, 1961.

-----. *Standard Specifications for Highway Bridges*. 9th ed. Washington, D.C.: American Association of State Highway Officials, 1965.

-----. *Standard Specifications for Highway Bridges*. 10th ed. Washington, D.C.: Association General Offices, 1969.

American Institute of Steel Construction. “Prize Bridge: 1960’s Winners.” http://www.aisc.org/contentNSBA.aspx?id=21368 (accessed 20 January 2010).

American Institute of Steel Construction. “Prize Bridge Competition: Previous Winners.” http://www.aisc.org/contentNSBA.aspx?id=20760 (accessed 20 January 2010).

“A New Home for Headquarters.” *Utah Highways and Byways* 1, no. 11 (August 1958): 3.

Barnett, Joseph. "Road Design: Some Modern Aspects." *Traffic Engineering* 34, no. 4 (January 1964): 22.

Benjamin, Irwin A. "Composite Beams of Steel and Lightweight Concrete." *AISC Engineering Journal* (October 1965): 125.

Benson, Lee. “Bus crash in 1938 led to train laws.” *Deseret News* (Salt Lake City). 21 October 2009. http://www.deseretnews.com/article/705338209/Bus-crash-in-1938-led-to-train-laws.html?pg=1 (accessed 5 June 2011).

Billington, David P. "Bridges and the New Art of Structural Engineering." in *Bridge Aesthetics Around the World,* 72. Washington, D.C.: Transportation Research Board, National Research Council, 1991.

“Bridge Design Division – Century and a Half of Service.” *Utah Highways and Byways* vol.1, no. 8 (May 1958): 2.

"Bridge Evolution: Many Factors at Work in Billion-A-Year Program." *Roads and Streets* 111, no. 1 (January 1968): 203.

“Burton Says State Should Safeguard Highway Funds.” *Utah Highway Progress* 3, no. 4 (30 March 1960): 1.

“Cache Valley Construction Opens Recreation Areas.” *Utah Highways and Byways* 2, no. 12 (September 1959): 3.

California Division of Highways. *Manual of Bridge Design Practice*, 2d ed. [Sacramento, Calif.]: State of California Highway Transportation Agency, Department of Public Works, Division of Highway, Bridge Department, 1963.

“Cart Creek Bridge Construction near Flaming Gorge Dam.” *Utah Highways and Byways* Vol. 5, nos. 11-12 (August-September 1962): 3.

Carver, George L. "The Interstate System Survey," in *Proceedings of the Twenty-Third Annual Short Course in Highway Engineering*, ed. Fred J. Benson. College Station, Tex.: Texas Engineering Experiment Station, A&M College of Texas, 1949.

“Commission Inaugurates Dollar Stretching Program.” *Utah Highways and Byways* 3, no. 2 (November 1959): 4.

“Commission Inaugurates Dollar Stretching Program.” *Highway Progress* 2, no. 12 (25 November 1959): 1.

"Concrete Bridges Outnumber Steel." *Engineering News-Record* 165 (6 October 1960): 22.

Condit, Carl W. *American Building: Materials and Techniques from the First Colonial Settlements to the Present*. 2d ed. Chicago: University of Chicago Press, 1982.

“Consulting Engineer Work Underway.” *Utah Highways and Byways* 1, no. 5 (February 1958): 1.

Culver, Charles, Darryl Brogan, and David Bedner. "Analysis of Curved Girder Bridges." *AISC Engineering Journal* (January 1970): 10.

Dean, W. E. "Continuous and Cantilever Bridges with Precast-Prestressed Concrete Beams." in *Proceedings Convention Committee Meeting Papers, New York, New York, October 5-7, 1965,* 267-268. Washington, D.C.: American Association of State Highway Officials, General Offices, 1965.

“Defense Road Dedicated.” *Utah Highways and Byways* 4, nos. 11-12 (August-September, 1961): 8.

“District 1.” *Utah Highways and Byways* 1, no. 12 (September 1958): 4.

“District 6.” *Utah Highways and Byways* 1, no. 10 (July 1958): 3.

“District 6.” *Utah Highways and Byways* 3, no. 3 (December 1959): 3.

“District 6.” *Utah Highways and Byways* 3, no. 5 (February 1960): 4.

Duwadi, Sheila R. and Michael A. Ritter. "Timber Bridges in the United States." *Public Roads* 60, no. 3 (winter 1997): 5.

Dyment, Robert G. "Experience Aids Engineers in Welded Steel Bridge Design." *Consulting Engineer* (October 1956): 66.

Elliott, A. L. "How To Use High-Strength Steel Effectively." *Engineering News-Record* 164 (18 February 1960): 52-56.

Erickson, Eric L. and Neil Van Eenam. "Application and Development of AASHO Specifications to Bridge Design." *Journal of the Structural Division Proceedings of the American Society of Civil Engineers* ST4 (July 1957): 1320-16.

Federal Highway Administration. "Brief History of the Direct Federal Highway Construction Program," http://www.fhwa.dot.gov/infrastructure/blazer01.htm (accessed 12 December 2010).

-----. "The Dwight D. Eisenhower National System of Interstate and Defense Highways," Federal Highway Administration. http://www.fhwa.dot.gov/reports/routefinder/ (accessed 15 December 2009).

"Financing Utah's Highways." *Utah Highway Progress* 4, no. 1 (12 January 1961): 1-2.

"First Phase Personnel Program Underway." *Utah Highways and Byways* 1, no. 6 (March 1958): 4.

Fisher, John, et al. "Steel Bridges in the United States: Past, Present, and Future." *Transportation Research Circular* E-C104 (September 2006): 36.

"Five-Man Commission Observes First Birthday." *Utah Highways and Byways* 1, no. 7 (April 1958): 1.

Flink, James J. *The Car Culture*. Cambridge, MA: MIT Press, 1975.

Fraser, Clayton. "Historic Overview," 1997. Available at Utah Department of Transportation, Salt Lake City, Utah.

Gerwick, Ben C. "Precast Segmental Construction for Long-Span Bridges." *Civil Engineering* 34 (January 1964): 44.

Gillespie, James W. "Analysis of Horizontally Curved Bridges." *AISC Engineering Journal* (October 1968): 137-138.

"Glen Canyon Road Gets Official Opening." *Utah Highways and Byways* 2, no. 1 (October 1958); 4.

Grossman, Stanley. "Short Span Highway Bridges with Wide Stringer Spacing and a Two-way Reinforced Concrete Deck." *AISC Engineering Journal* (April 1965): 55.

Grover, La M. "Welding for Bridges." *Civil Engineering* 33 (December 1963): 60-63.

Handbook of Steel Drainage & Highway Construction Products. 3rd ed. Washington, D.C.: American Iron and Steel Institute, 1983.

Henneberger, Wayne. "High Tensile Bolting of Highway Structures." *The Texas Engineer* 27, no. 7 (August 1957): 9.

Hewes, Laurence I. and Clarkson H. Oglesby. *Highway Engineering.* New York: John Wiley & Sons, Inc., 1954.

Higgins, T. R. and Mace H. Bell. "High-Strength Bolts - A New Structural Fastener." in *Proceedings of the Texas Structural Engineering Conference, March 21-22, 1952,* 43. Austin, Tex.: The University of Texas, Department of Civil Engineering and Bureau of Engineering Research, [1952].

Hill, L.E. “Prestressed Concrete Now a Standard Product.” *PCI Journal* (May 1956): 52.

Hokanson, Drake. *The Lincoln Highway: Main Street Across America*. Iowa City, Iowa: University of Iowa Press, 1988.

Holland, Vance M. “Utah’s Highway Construction Program Progresses on Schedule.” *Utah Highways and Byways* 5, nos. 6-9 (June 1962): 5.

Hoyt, Charles H. and William H. Burr. *Highway Bridges and Culverts*, *U.S. Department of Agriculture, Office of Public Roads - Bulletin No. 39.* Washington, D.C.: Government Printing Office, 1911.

“IBM Installation Cuts Engineering Time.” *Utah Highways and Byways* 2, no. 4 (February 195[9]): 4.

“Interstate System in Perspective.” *Utah Highways and Byways* 1, no. 8 (May 1958): 1.

Johnson, A. E., ed., *Published on the Occasion of the Golden Anniversary American Association of State Highway Officials: A Story of the Beginning, Purposes, Growth, Activities and Achievements of AASHO.* Washington, D.C.: The American Association of State Highway Officials, 1965.

JRP Historical Consulting Services. *Historic Context Statement: Roadway Bridges of California: 1936 to 1959*. (Prepared for State of California Department of Transportation, January 2003).

“Kane County Project Eliminates Dangerous Section of US Highway 89.” *Utah Highways and Byways* 5, nos. 4-5 (January-February 1962): 3.

Kaszynski, William. *The American Highway: The History and Culture of Roads in the United States*. Jefferson, N.C.: McFarland & Company, Inc., 2000.

Kerensky, O. A. "Critical Survey of Bridge Design." *Engineering* (11 September 1959): 181-182.

Knowlton, Ezra. *History of Highway Development in Utah*. Salt Lake City: Utah State Road Commission, [1967].

Lewis, Tom. *Divided Highways: Building the Interstate Highways, Transforming American Life*. New York: Viking, 1997.

Lichtenstein Consulting Engineers. *The Third Ohio Historic Bridge Inventory, Evaluation, and Management Plan for Bridges Built 1951-1960 and the Development of Ohio's Interstate Highway System.* [Columbus], Ohio: Ohio Department of Transportation, 2004.

Lin, Tung Y. *Design of Prestressed Concrete Structures.* New York: John Wiley & Sons, Inc., 1955.

-----. *Design of Prestressed Concrete Structures*, 2nd ed. New York: John Wiley & Sons, 1963.

-----. “Economics of Prestressed Concrete.” *PCI Journal* (December 1956): 48-56.

Lin, Tung Y. and Felix Kulka. "Fifty-Year Advancement in Concrete Bridge Construction." *Journal of the Construction Division, Proceedings of the American Society of Civil Engineers* 101, no. CO3 (September 1975): 494-495.

Loutzenheiser, Donald W. "New Concepts for Urban Freeway Interchanges." *Journal of the Highway Division: Proceedings of the American Society of Civil Engineers* 88, no. HW1: 31, 36.

Lyman, Edward L. “The Arrowhead Trails highway: The Beginnings of Utah’s Other Route to the Pacific Coast.” *Utah Historical Quarterly*, 1942.

McGrath, Timothy J., et.al. “Culverts: Hidden Structures, Critical Infrastructure Elements.” *Transportation Research Circular* E-C104 (September 2006), 109-120. http://onlinepubs.trb.org/onlinepubs/circulars/ec104.pdf (accessed 8 February 2010).

Munse, W. H. "High-Strength Bolting." *AISC Engineering Journal* (January 1967): 36.

“New Bridge Spans Green River for Flaming Gorge Access.” *Utah Highways and Byways* 2, no. 5 (March 1959): 3.

“New Highway Construction Brings Added Terminology.” *Utah Highways and Byways* 1, no. 1 (October 1956): 4.

“New Home for Department of Highways.” *Utah Highways and Byways* 3, no. 7 (April 1960): 1.

“New Section of Magna-Garfield Highway Ahead of Schedule.” *Utah Highways and Byways* 4 no.9-10 (June-July 1961): 3.

“New Structure Division Formed.” *Utah Highways and Byways* 1, no.12 (September 1958): 1.

“Official Ceremonies Mark Completion of Bridge Link.” *Utah Highways and Byways* 2, no. 8 (June 1959): 1-2.

Olson, James S., ed. *Historical Dictionary of the New Deal*, Greenwood Press, 1985.

“Organization Gets Overhaul.” *Utah Highways and Byways* 2, no. 2 (November 1958).

Parsons Brinckerhoff and Engineering and Industrial Heritage. *A Context for Common Historic Bridge Types, NCHRP Project 25-25, Task 15.* [Washington, D.C.]: National Cooperative Highway Research Program, Transportation Research Board, 2005.

Patton, Phil. *Open road: a celebration of the American highway*. New York: Simon and Schuster, 1986.

Procedure Handbook of Arc Welding Design and Practice. 11th ed. Cleveland, Ohio: Lincoln Electric Company, 1957.

Reisner, Marc. *Cadillac Desert: The American West and Its Disappearing Water.* New York: Penguin Books, 1986.

Research Council on Structural Connections. "Minutes of [First] Meeting, Research Council on Riveted & Bolted Structural Joints, New York City, January 15, 1947." Research Council on Structural Connections. http://www.boltcouncil.org/files/OriginalMinutes.pdf (accessed 29 February 2008).

-----. "Research Council on Structural Connections, Background and Scope." Research Council on Structural Connections. http://www.boltcouncil.org/files/RCSCApplication.pdf (accessed 29 February 2008)

"Right of Way Revolving Fund Asked by Commission." *Utah Highway Progress* 2, no. 13 (January 1959): 1.

Scott, Norman L. "Suggestions for Reducing Costs in Prestressed Concrete Bridges." in *Highway Research Record Number 34: Bridge Design, Analysis, and Costs, 117.* Washington, D.C.: Highway Research Board, 1963.

Seely, Bruce. *Building the American Highway System: Engineers as Policy Makers.*(Philadelphia, Penn.: Temple University Press, 1987.

"Settling the Dust on Highway Financing," *Utah Highway Progress* 2, no. 7 (29 July 1959): 1.

"State appoints New Road Assistant for Contracting Engineering." *Utah Highways and Byways* 1, no. 11 (August 1958): 4.

"State Crews Commence Salt Lake Freeway." *Utah Highways and Byways* 2, no. 4 (February 195[9]): 2.

"State Highway Financing." *Utah Highways and Byways* 2, no. 12 (September, 1959).

State of Utah. *Compiled Digest of Administrative Reports for Fiscal Year Ended June 30, 1959 to the Legislature, the Governor and for Other Essential Purposes*. Salt Lake City: State of Utah, 1959.

-----. *Compiled Digest of Administrative Reports for Fiscal Year Ended June 30, 1960 to the Legislature, the Governor and for Other Essential Purposes.* Salt Lake City: State of Utah, 1960.

-----. *Compiled Digest of Administrative Reports for Fiscal Year Ended June 30, 1963 to the Legislature, the Governor and for Other Essential Purposes*. Salt Lake City: State of Utah, 1963.

-----. *Compiled Digest of Administrative Reports for Fiscal Year Ended June 30, 1964 to the Legislature, the Governor and for Other Essential Purposes*. Salt Lake City: State of Utah, 1964.

-----. *Compiled Digest of Administrative Reports for Fiscal Year Ended June 30, 1966 to the Legislature, the Governor and for Other Essential Purposes.* Salt Lake City:[State of Utah], 1966.

State of Utah Department of Engineering. First through Twenty-fourth Biennial Reports. 1909-1956. Salt Lake City: State of Utah, 1946.

State Road Commission of Utah. “Federal-aid for Highways in Utah.” [Salt Lake City]: State Road Commission of Utah, 1958. Available at University of Utah Marriot Library, Special Collections, Salt Lake City, Utah.

State Road Commission. “Road Map of Utah.” 1940. Available at University of Utah Marriott Library Special Collections, Salt Lake City, Utah.

Tentative Standards for Prestressed Concrete Piles, Slabs, I-Beams and Box Beams for Bridges and an Interim Manual for Inspection of Such Construction. Washington, D.C.: American Association of State Highway Officials, 1963.

Thatcher, W.M. "Horizontally Curved Steel Girders-Fabrication and Design." *AISC Engineering Journal* (July 1967).

“Unique Ceremony Marks Opening of Freeway.” *Utah Highways and Byways* 1, no. 5 (February 1958): 4.

United States Bureau of Public Roads. *Criteria for Prestressed Concrete Bridges.* Washington, D.C.: G.P.O., 1954.

-----. *Standard Plans for Highway Bridges, Vol. 1, Concrete Superstructures*, *Rev. ed*. Washington, D.C.: G.P.O., August 1968.

-----. *Standard Plans for Highway Bridge Superstructures*, 2d ed. Washington, D.C.: G.P.O., 1956.

Utah Department of Highways. “Utah Federal-aid Interstate System Map, 1966-1967.” Available at University of Utah Marriot Library, Special Collections, Salt Lake City, Utah.

-----. “Utah Federal-aid Interstate System Map, 1967-1968.” Available at University of Utah Marriot Library, Special Collections, Salt Lake City, Utah.

-----. “Utah Federal-aid Interstate System Map, 1970-1971.” Available at University of Utah Marriot Library, Special Collections, Salt Lake City, Utah.

Utah Department of Transportation, *Bridge Inventory Database,* 2009.

Utah Highways and Byways. “Bridge Design Division Century and Half of Service,” *Utah Highways and Byways* 1, no. 8 (May 1958): 4.

-----. *Standard Specifications for Road and Bridge Construction*. Salt Lake City: Utah State Road Commission, 1952.

-----. *Standard Specifications for Road and Bridge Construction.* Salt Lake City: Utah State Road Commission, 1960.

-----. “Structures 20 foot span or over on State Road System March 1, 1957.” [Salt Lake City]: N.P., 1957. Available at University of Utah, Marriot Library Special Collections, Salt Lake City.

“Utah Steel Returns to Highway Job.” *Utah Highways and Byways*, Vol. 3, no. 12 (September 1960): 2.

“Utah to be Link in New Interstate Highway System.” *Utah Highways and Byways* 1, no. 1 (Oct 1957): 4;

Weingroff, Richard F. "Federal-Aid Highway Act of 1956: Creating the Interstate System," Federal Highway Administration. http://www.fhwa.dot.gov/infrastructure/rw96e.htm (accessed 12 December 2010).

-----. “From Names to Numbers: The Origins of the U.S. Numbered Highway System,” Federal Highway Administration, http://wwwcf.fhwa.dot.gov/infrastructure/numbers.cfm.

Work Projects Administration. *Final Statistical Report of the Federal Emergency Relief Administration*. Washington, D.C.: U.S. Government Printing Office, 1942.

Appendix A. Fraser Design's Study of Utah Bridges Built Prior to 1946

Fluctuating waterways, diverse natural landmarks, and semiarid conditions combine to test the creativity of bridge builders in Utah. West of the Rocky Mountains and situated midway between Canada and Mexico, Utah is the nation's eleventh largest state. It is effectively bisected by the Wasatch Mountain Range, extending north-south through the state's center.[1] Altitude determines climate and precipitation within the region, and, accordingly, the higher elevations receive a disproportionately higher degree of rainfall and climate vicissitude. Owing to Utah's overall semiarid climate, water is regarded as a precious resource. The Green and the Colorado are the region's largest rivers. Historically called the Grand River, the Colorado enters Utah through the Grand Valley northeast of Moab. It flows southwesterly through a series of progressively deeper gorges before leaving the state just north of Page, Arizona.

The Green River enters Utah from Wyoming in Dinosaur National Monument and continues its winding path south through Desolation Canyon and Gray Canyon before joining with the Colorado at Island in the Sky in Canyonlands National Park. Both the Colorado and Green Rivers experience enormous fluctuations in volume as a result of seasonal changes in precipitation. A third river, the San Juan, also changes dramatically in character as it cuts across Utah's remote southeastern corner. The majority of other streams are small-scale, short in length, and their water levels vary with the changing seasons. Many streams engorged with spring rain runoff are frequently parched by late summer.[2]

Early explorers and fur trappers lamented the region's challenging environment as they searched for virgin trapping grounds or direct routes to California. In order to pass through Utah, a traveler could expect to encounter a variety of major obstacles, including deserts, which cover a third of the state. One writer recalls his unforgettable journey through Utah: "Before men and animals could conquer its wearisome length, a mighty river had to be circumnavigated. Mountain passes, precipitous canyons, and sandy arroyos must be threaded. Gigantic ranges, broken plateaus, and waterless mesas were to be overcome and the entire course was through unmapped land..."[3]

It is generally acknowledged that the first Anglo explorers to venture into Utah were Atanasio Dominguez and Silvestre Valez de Escalante, Catholic priests looking for a route between California and the missions in New Mexico. Undertaken in 1776, the Dominguez-Escalante expedition entered the state near Jensen and traversed southwest to St. George before doubling back eastward toward New Mexico. They were the first to cross the Colorado River in northern Arizona at a place later called *Vado de los Padres*, or "Crossing of the Fathers".[4]

Another route used to link Santa Fe and Los Angeles through Utah was the old Spanish Trail. Between 1813 and the 1850s, travelers crossed this route, entering Utah near Monticello, looping north of the San Rafael Swell and swinging southerly to Utah's southwest corner. Captain John William Gunnison followed the Spanish Trail as he searched for a transcontinental rail route in 1853. "As we approached the river yesterday," he wrote in his journal, "the ridges on either side of its banks to the west appeared broken into a thousand forms–columns, shafts, temples, buildings, and ruined cities could be seen, or imagined, from the high points along our route."[5]

Jedediah Smith was responsible for exploring much of the state in the 1820s in his quest "to view a country on which the eyes of a white man had never gazed and to follow the course of rivers that run through a new land."[6] He was followed in the 1840s by other adventurous trappers such as Peter Skeene Ogden, Ewing Young and Kit Carson and by military explorers such as John Fremont and John Gunnison.[7] The first emigrants to cross the region in wagons were the Bartleson-Bidwell Party, skirting the Bear River region in northern Utah in 1841. These earliest forays blazed important trails into the region but did little to improve the routes into permanent thoroughfares. Little is known about bridge construction practices of this exploratory period. No bridges survive from this time, and even documentary evidence is rare. It seems fairly certain, however, that the earliest bridges were hurriedly and crudely built using nearby materials and intended to serve only as long as it took their builders to cross one time.

Six years after the Bartleson-Bidwell Party passed through Utah, the first phalanx of Latter Day Saint immigrants arrived in 1847. They brought with them the seeds of settlement, which quickly flourished. With their church-sponsored social structure, the Mormons formed a well-organized community that almost immediately began re-shaping the land for their own needs. Mormon immigrants flooded to the region in successive waves throughout the mid-19th century, quickly fanning out from the initial settlement in Salt Lake City to form outlying colonies throughout Utah, Idaho and northern Arizona. "The founding, within the space of three years, of a large and flourishing community," Howard Stansbury wrote in 1852, "upon a spot so remote from the abodes of man, so completely shut out by natural barriers from the rest of the world, so entirely unconnected by watercourses with either of the oceans that wash the shores of this continent–a country offering no advantages of inland navigation or of foreign commerce, but on the contrary, isolated by vast uninhabitable deserts, and only to be reached by long, painful, and often hazardous journeys by land–presents an anomaly so vert peculiar, that it deserves more than a passing notice."[8]

With breathtaking industry, the Mormons immediately began building a network of roads and trails to link the settlements throughout the region. The first notice of bridge construction came in an epistle of the High Council, issued in March 1848, that directed Jedediah Grant, John Spencer and Stephen Chipman to build bridges over Mill Creek and the Jordan River in Salt Lake City.[9] Spencer was designated by the Council as "Pathmaster," in charge of road construction and maintenance throughout the Salt Lake Valley. But he and the Council faced initial difficulties in organizing road-building among a settlement that was starting, literally, from scratch. "We tried faithfully to have bridges built and roads made by the 'hundreds,' but had to abandon the idea and try direct labor tax on polls and property."[10]

In 1848 Spencer was replaced as road overseer by Joseph L. Heywood, who built a road and five bridges to the warm springs north of the city. These five spans and the two earlier bridges were mentioned in a report made by the church that appeared in the *New York Herald Tribune* in June 1849: "Our public works are progressing... a bridge across the western Jordan has been built at an expense of $700, and six or seven bridges across the minor streams to be paid by a one cent property tax."[11] An organized system of roads soon began to take form, as Parley Pratt wrote in 1851: "One may now ride on a good carriage road from Brownsville on the Weber River on the north, to Provo River of Utah County on the south, a distance of near 100 miles... Good frame bridges are already completed across many of the streams."[12]

Joseph Heywood was one of the first-named officers of the State of Deseret, established by the Mormons in March 1849.[13] The newly formed government quickly turned to road matters, enacting "An Ordinance Providing for State and County Road Commissioners" a month after their initial legislative session in December 1849. The new ordinance established the office of State Road Commissioner–to be elected to a two-year term by the General Assembly–and directed the commissioner to designate, survey and build state roads and to "make contracts for building bridges, aqueducts, culverts, turnpikes and all other fixtures necessary for the completion of any public road." The act also directed the counties to appoint their own road commissioners, who would function in much the same way for county-level roads.[14] As municipalities such as Salt Lake City, Ogden, Manti, Provo and Parowan were chartered, they too took on responsibility for street and bridge construction within their jurisdictions.[15]

Perhaps the most prominent of these early city-built bridges was the all-timber White Bridge over the Jordan River in Salt Lake City (*see Figure 1*). Comprised of a Town lattice truss, the White Bridge was a marvel, not of engineering, but that it stood up at all. Its completion in August 1854 marked only the beginning of an almost continuous string of repairs and replacements, as the bridge stood in varying degrees of collapse throughout its history. By March 1857 "a number of pieces of timber had been knockt [sic] or cut therefrom... If props and timber be placed under said bridge, it would be a temporary preservation against the bridge falling to pieces, and the danger of herds of cattle falling through."[16] Two months later the bridge required continual watching and propping, "as many herds of cattle were crossing it run on by herd boys."[17] By June 1857 the bridge required major repairs, as recommended by the Committee on Improvements:

> Good substantial stone peers [sic] are needed to secure the present bridge for several years and when necessary to erect a new one on said piers, but more particularly to prevent the constant expenditures to which the bridge in its present condition is liable as well as preventing the hazardous risk of loss of life to which the state of the bridge now subjects the citizens who cross it.[18]

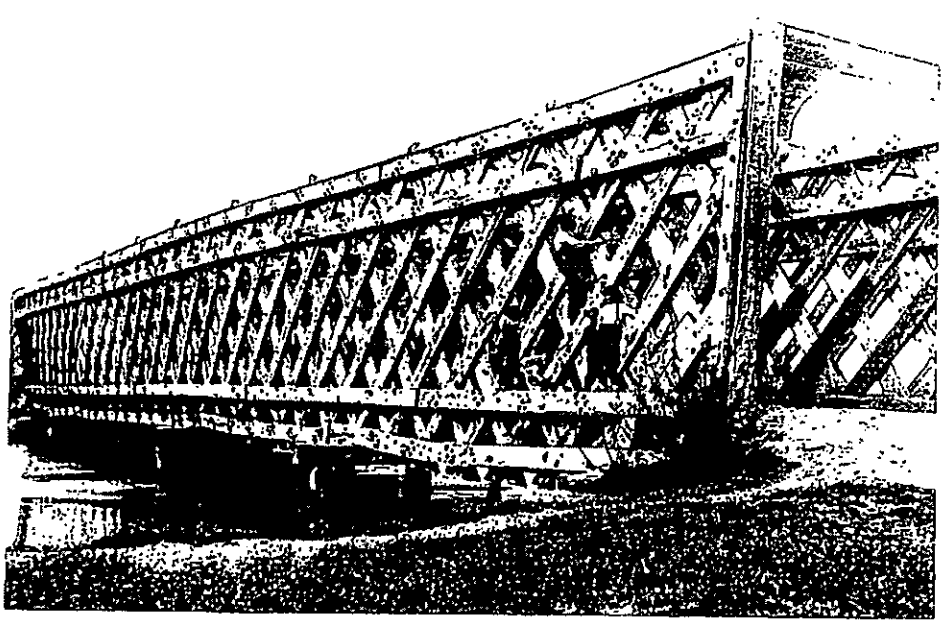

Figure 1. Jordan River Bridge, 1907, from Utah State Historical Society.

The State of Deseret proved even shorter lived than the bridge. It lasted only until September 1851, at which time it was superseded by the designation of Utah Territory by the federal government. Carried over to the territorial government, the 1849 road legislation provided the framework for highway administration throughout the territory that would last into the 20th century. But the industry and organization that had characterized the first four years of settlement soon deteriorated into a state of disarray in the hands of the territorial government. Comprised of Washington appointees and locally elected officials, the territorial government was reduced to factionalism between government appointees and the Mormon populace that "varied at best from coolness and lack of understanding to almost utter contempt, which at times bordered on the brink of open warfare."[19]

The territorial government tried to accomplish with poll taxes what the Mormon church had done through tithing, with far less success. "That a poll tax for road purposes, which most Yankees think very essential to the making and keeping of public roads in repair, as a general thing is a great humbug, we well know, having witnessed its practical application in many instances," the *Deseret News* editorialized.[20] In the face of lagging revenues, the territorial legislature had to rely heavily upon toll franchises for roads and bridges. Many of these latter structures rarely lasted beyond the statutory limits of the franchise. Often poorly constructed and unevenly maintained, these crude structures typically washed out in floods or collapsed under load.

One of the most important bridges built during the period was the reconstruction of the White Bridge under the supervision of Territorial Road Commissioner Theodore McKean in 1860.[21] That same year the territorial legislature began revoking the franchises for toll roads, assuming their operation itself. The process was slow and incremental, however, and private toll road operators were still in business when the first transcontinental railroad was linked at Promontory in 1869.

Utah's most historically significant extant wagon bridge–the Bigler's Crossing Bridge [Box Elder County; **003067C**] over the Bear River–dates from the territorial period. Like many of the region's most important crossings, this bridge was preceded by a ferry boat operation. But even before the ferry was established, this site served as a ford in the river for explorers John Fremont, Samuel Hensley, Howard Stansbury and numerous others traveling along the Salt Lake Cutoff on their way to California.[22] In 1853 Benjamin Y. Hampton and William S. Godbe established a ferry at this site, charging 10 cents for each horse and 25 cents per wagon. Six years later they replaced their ferry with a timber bridge, comprised of 11 kingpost spans supported by stone-filed log crib piers. The bridge was later rebuilt on the original piers, and a charter for its toll operation was granted in 1866 by the Church. That year Hampton built a two-story stone house just south of the bridge. The house also served as the Bear River Hotel, later described by Arnold Standing:

> Built of limestone obtained from a quarry located a short distance east of Collinston, the walls were about two feet thick. The hotel had eighteen rooms, including ten rooms on the second floor that were reached by a stairway from the entrance hall. On the first floor, at the front or north end of the house, were two large rooms used as a sitting room and a parlor. A large fireplace provided both physical and friendly warmth. At the back, or south end of the house, was a large kitchen. A dining room occupied the space between the kitchen and sitting room. There was an outside "necessary house" just east f the house. And in keeping with the grandeur of the establishment, it was carpeted, plastered and wallpapered.[23]

In 1875 James Standing acquired the bridge and house, continuing its operation as a regionally important crossing. The timber bridge constructed by Hampton and Godbe offered feeble resistance to natural forces, however. Its trussed superstructure and cribbed piers required almost constant maintenance to keep the bridge serviceable. In 1892 an all-metal bridge was built here to replace the earlier timber structure. The log piers were replaced with stone masonry, and the series of kingpost trusses was replaced with three continuous Warren pony trusses, each 73-foot span comprised of 12-rigid-connected panels. The new bridge was made up of components rolled by the Phoenix Iron Works of Phoenixville, Pennsylvania.

With the truss components shipped to the site by wagon, a premium was placed on lightweight construction. Rather than the traditional boxed configuration of the upper chords and endposts, the new structure used paired angles with continuous plates. Further, the trusses' continuous configuration eliminated to need for duplicate bearing shoes required by simply supported spans. Dedicated on July 4, 1892 (see *Figure 2*), the Hampton Bridge or Bear River Bridge was later called the Bigler's Crossing Bridge. It carried wagon and automobile traffic for nearly a century before Box Elder County closed it in 1990[24]

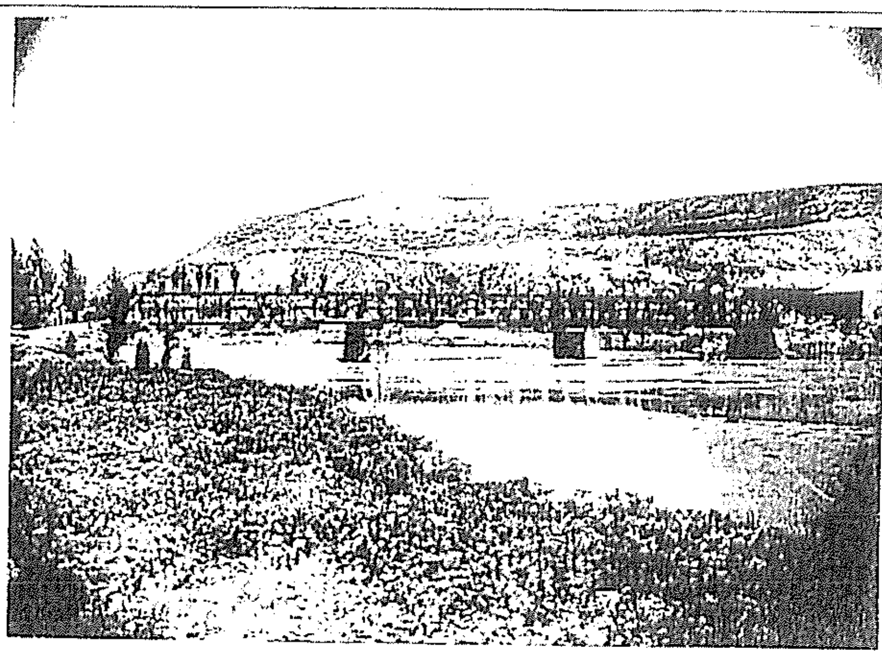

Figure 2. Bigler's Crossing Bridge, 1892, from Special Collections, Utah State University

Bridge design in Utah during the 19th century was largely an empirical process, dependent upon the experience and judgement of local engineers, surveyors or carpenters. To span the multitude of washes, streams, runs, gullies, ravines and irrigation ditches that criss-crossed the region, small-scale timber stringer spans were used extensively. Though inexpensive to build, most of these bridges tended to be structurally suspect and required frequent maintenance to prevent their collapse. Moreover, they were limited to short-span applications. Timber/iron kingpost and queenpost combination trusses were used for crossings that required longer spans. With origins dating back to the Middle Ages, the kingpost pony was the most rudimentary truss type, limited by its configuration to relatively short spans (see *Figure 3*). Longer bridges, such as the White Bridge over the Jordan River, used Town lattice or Howe trusses. Patented in 1840 by William Howe of Massachusetts, the Howe truss featured wooden diagonals in compression and iron verticals in tension (see *Figure 4*). Howe trusses were used extensively for railroad and wagon bridges through the mid-19th century, when a series of disastrous and well-publicized railroad bridge failures illustrated their inherent weaknesses.

Figure 3. Kingpost truss schematic

All of these wooden bridges could be fabricated and built using local labor. For metal bridge superstructures of any complexity, however, the counties were compelled to contract with out-of-state bridge building companies, for the simple reason that no in-state firms then existed. Such industry giants as the Wrought Iron Bridge Company of Canton, Ohio, and the King Iron Bridge Company of Cleveland – America's two most prolific wagon bridge fabricators in the 1870s and 1880s – apparently did no work in the state. But a number of other national and regional firms provided superstructures to Utah's counties and in some cases erected the bridges as well. Among the firms active in the state were the Missouri Valley Bridge and Iron Company of Leavenworth, Kansas, the Pueblo Bridge Company of Pueblo, Colorado, the Denver Bridge Company of Denver, Colorado, the Elkhart Bridge and Iron Company of Elkhart, Indiana, the Joliet Bridge Company of Joliet, Illinois, and the Vincennes Bridge Company of Vincennes, Indiana.

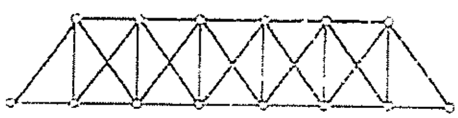

Figure 4. Howe truss schematic

Denver engineer Marcus J. Patterson acted as the agent for P.E. Lane of Chicago, whose company, the Lane Bridge and Iron Works, was responsible for fabricating Utah's oldest extant highway truss, the Bear River City Bridge [Box Elder County; 003055C]. This two-span iron structure was built over the Bear River just east of Bear River City (see *Figure 5*). Comprised of two Pratt through trusses on stone masonry abutments and pier, the Bear River City Bridge featured typical pin-connected detailing, with laced endposts, punched eyebars and floor beams U-bolted to the lower chord pins. It was fabricated from wrought iron components rolled in the Carnegie mills and erected at this pivotal crossing in 1889.

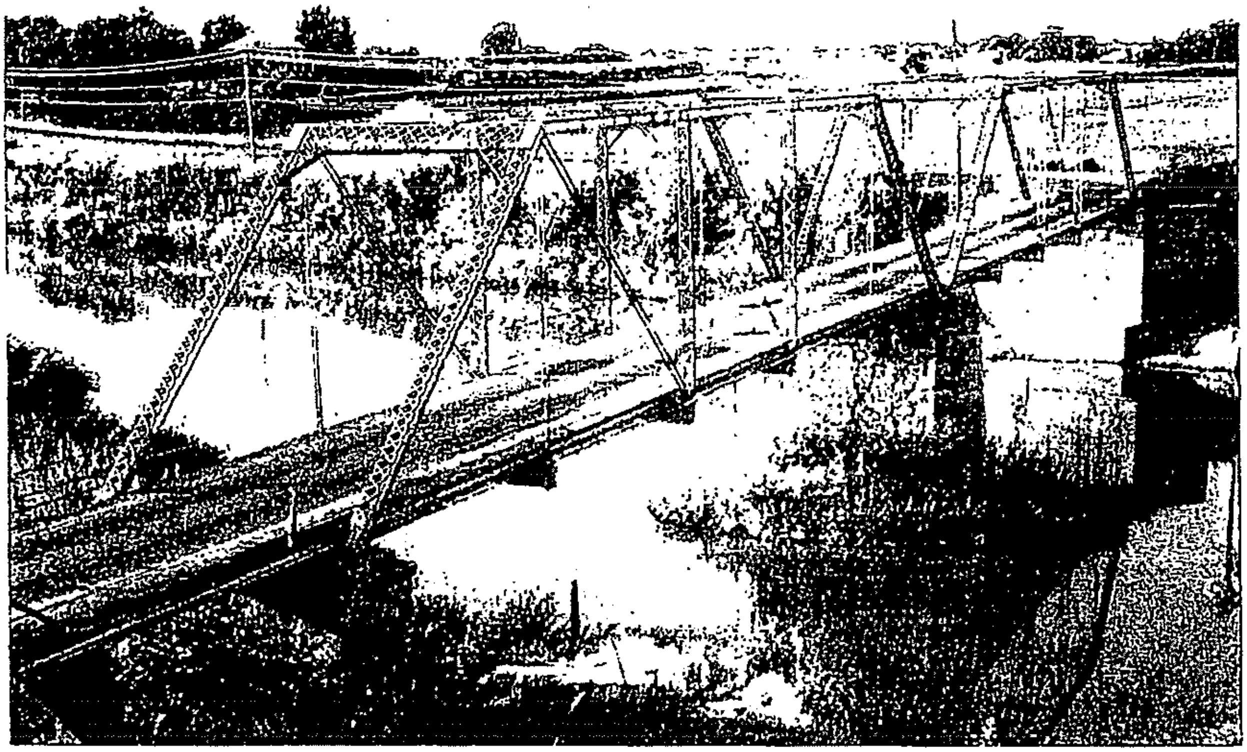

Figure 5. Bear River City Bridge, by Clayton Fraser, 1992.

With the counties contracting for bridge work on an increasing basis at the turn of the century, an indigenous bridge industry began to emerge that would compete with the national firms. Local carpenters or masons could build the small-scale spans as a sideline to their work on buildings. Larger, more complex steel superstructures and substructures that involved extensive pile-driving required fabrication and erection equipment beyond the capacity of most building contractors, however. The first in-state bridge firm listed in the Salt Lake City business directory was the Andrews Bridge Company, operated by James C. and Allison G. Andrews beginning sometime before 1898. Andrews Bridge had apparently quit business by 1900. The company was replaced a year after that by Dederichs and Burke. Comprised as a partnership between Joseph Dederichs and James J. Burke, the firm listed itself as civil engineers, bridge contractors and agents for the Gates Iron Works of Chicago (*see Figure 6*).

James Joseph Burke, on his own two years later, would eventually emerge as Utah's most prolific bridge builder. Born in Pittsburgh on January 15, 1874, he was first employed as a draftsman for Westinghouse after graduating from Duquesne University. Burke then worked for the Carnegie Steel Company and the

Pittsburgh Bridge Company, drafting shop drawings for bridges. In 1898 he moved west to Great Falls, Montana, where he served as a draftsman and engineer for the Anaconda Copper Mining Company. After a year, Burke moved to Salt Lake City, working for the International Smelting and Refining Company in Murray before he joined in partnership with local contractor Joseph Dederichs.

DEDERICHS & BURKE,
ENGINEERS AND CONTRACTORS.
Mining and Milling Machinery and Steel Construction.
Plans and Specifications Furnished on Application.
Smelters, Cyanide Mills, Stamp Mills, Lixiviation Plants, Hoisting Works, Tramways, Etc.
229-230 ATLAS BLOCK, Telephone 761.

Figure 6. Advertisement, from Salt Lake City Directory, 1901.

The two split the partnership in 1903. Burke continued to build bridges. In addition, he served as an engineer and agent for Charles C. Moore and Company, a power plant manufacturer that was based in San Francisco. In 1910 he incorporated as James J. Burke and Company, Inc., Engineers and Contractors, with T.A. Beyer as vice president and F.E. Arnold as secretary/treasurer (see *Figure 7*). The firm erected steel trusses and other highway bridges throughout Utah and Wyoming and built such Salt Lake City landmarks as the Tribune-Telegram Building, the Medical Arts Building and South High School, in addition to industrial plants in Utah, Idaho, Montana and Nevada. Burke continued building bridges and buildings until his death in 1944 at the age of 70, at which time Arnold took over control of the company, operating it to the present.[25]

JAS. J. BURKE & CO., (Inc.)
ENGINEERS AND CONTRACTORS
Highway Bridges, Grain Elevators and Steel Construction of all kinds Complete Mining and Smelting Plants Installed Under One Management. Satisfaction Guaranteed. Elevated Trestle and Heavy Timber Work a Specialty. Plans and Specifications for Mills and Smelters Furnished.
BOTH TELS. 761 303-304-305 ATLAS BLOCK

Figure 7. Advertisement, from Salt Lake City Directory, 1911

Burke competed for county bridge business with such out-of-state bridge firms as the Midland Bridge Company of Kansas City, the huge American Bridge Company of New York, the Gillette-Herzog Manufacturing Company of Minneapolis, and the Minneapolis Steel and Machinery Company. Acting as bridge a fabricator as well as an erector, the latter firm supplied Burke with many of the truss superstructures for his Utah bridges. For a brief time in 1906-1907, carpenter James Lambert contracted for bridges from his Salt Lake City offices (see *Figure 8*), but he died at the age of 35 in 1907. Many of the state's remaining trusses can be attributed to James Burke, including the Spring Glen Bridge [Carbon County; 007016C], the Helper Bridge [Carbon County; 007032C], the Mounds Bridge [Emery County; 015021C], the Bear River Bridge [Rich County; 033006C] and the Jensen Bridge [Uintah

County; OC 126]. Midland accounted for many of the others built between 1905 and 1915, including the Hot Springs Bridge [Washington County; 053013C], the Jordan River Bridge [Salt Lake County; 035112C] and the Jordan Narrows Bridge [Utah County; 049061C].

J. C. LAMBERT
CONTRACTING CARPENTER
Buildings, Bridges, Plans and Specifications
Bell Phone 4189-Y
226 WEST FOURTH SOUTH ST. SALT LAKE CITY

Figure 8. Advertisement, from Salt Lake City Directory, 1907.

Even in a secondary market such as Utah, with few major bridges built, the competition among bridge companies was intense. With contract awards made solely on the basis of cost, a premium was placed on efficiency of materials and erection. Companies like Missouri Valley Bridge and Iron maintained catalogues of bridge types, ranging from the exotic to the commonplace. MVB&I and most of the other 19th century bridge fabricators relied heavily on Pratt truss variants for their standard all-metal truss types. Patented in 1844 by Thomas and Caleb Pratt, the Pratt design was characterized by upper chords and vertical members acting in compression and lower chords and diagonals that acted in tension (see *Figure 9*). Its parallel chords and equal panel lengths resulted in standardized sizes for the verticals, diagonals and chord members, making fabrication and assembly relatively easy.

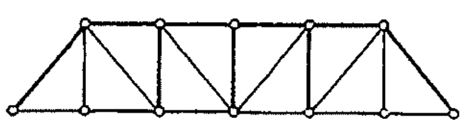

Figure 9. Pratt truss schematic.

In the highly competitive bridge manufacturing industry, in which efficiency equated with profit, Pratt trusses received almost universal use. "The Pratt truss is the type most commonly used in America for spans under two hundred and fifty feet in length," noted bridge engineer J.A.L. Waddell wrote in 1916. "Its advantages are simplicity, economy of metal, and suitability for connecting to the floor and lateral systems."[25] Virtually all of the major regional fabricators manufactured Pratt trusses and marketed them extensively to Utah's counties in the late 19th and early 20th centuries.

One of the more common Pratt truss sub-types was the Parker truss. Developed in the 19th century by C.H. Parker, the Parker truss incorporated web members similar to the Pratt truss in their distribution of compressive and tensile forces (see *Figure 10*). In this it resembled the venerable Pratt and was, in fact, universally regarded by civil engineers as a Pratt subtype. Waddell gave the Parker only passing mention in *Bridge Engineering*, stating: "[The Pratt's] chords are not necessarily parallel, but may be inclined. This latter form is frequently known as the Parker truss."[27]

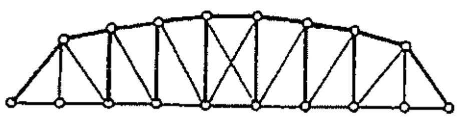

Figure 10. Parker truss schematic.

The inclined upper chords afforded a degree of efficiency in long span trusses, where bending moment stresses at mid-span greatly exceed the sheer stresses at the ends. The Parker's drawback was that, unlike the straight-chorded Pratt truss, the polygonal chords necessitated different-length verticals and diagonals at each panel, increasing its fabrication costs somewhat. Because trusses were generally priced on the basis of their superstructural weight, the lighter overall weight of a polygonal-chord truss more than offset the slight increase in fabricating costs in spans greater than 160 feet.

The Whipple truss also resembled the Pratt in its arrangement of compression and tension members (see *Figure 11*). Its primary difference lies in its diagonals, which extend over two panels. Patented in 1847 by esteemed civil engineer Squire Whipple, the Whipple (or double-intersection Pratt) truss was a popular choice for longer span crossings–generally in excess of 150 feet– between 1850 and 1900. Although more costly than the single-paneled Pratt, this variation provided greater lateral support for the diagonals, a critical consideration in deep, long-span trusses. Another long-span variant of the straight-chorded Pratt was the Baltimore truss, which employed sub-struts or sub-ties to brace the long two-panel diagonals (see *Figure 12*). As the Baltimore represents a sub-divided Pratt, the Pennsylvania truss is a subdivided Parker (see *Figure 13*).

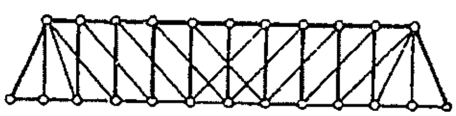

Figure 11. Whipple truss schematic.

Another common variant of the venerable Pratt truss was the half-hip truss (see *Figure 14*). Marketed extensively by the bridge companies, its primary advantage was that, by eliminating the vertical members at the hip connections, it was more materially conservant than the standard Pratt. Its disadvantage was that it was generally limited to short-span applications: typically 30-60 feet. But Utah's myriad small streams lent themselves to this range, and, as a result numerous Pratt half-hip pony trusses were erected in the state.

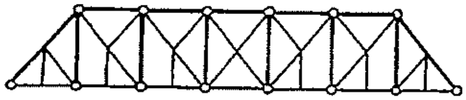

Figure 12. Baltimore truss schematic.

Evolution of truss components and connections paralleled that of truss design. Cylindrical pins were first used to connect metal truss members on a Lehigh Valley Railroad bridge in 1859. Two years later, a complementary truss member–the forged iron eyebar–was introduced. Eyebars appeared in the 1870s. Pinned connections, typically used on Pratt trusses, allowed quick erection, but they lacked rigidity and could loosen from vibrations caused by traffic and wind. Riveting created stronger, sturdier connections but was not practical in the field before portable pneumatic riveters became available in the late 1880s. In Utah Pratt trusses typically employed pinned connections until around 1910, when rigid connections began to supersede the older technology. Bridge fabricators such as the Midland Bridge Companies used both structural types during the transitional period after the turn of the century.

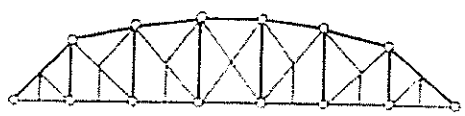

Figure 13. Pennsylvania truss schematic

In contrast with the Pratt truss, with its built-up verticals and lightweight eyebar diagonals, the Warren truss featured a series of diagonals that alternate between compression and tension (see *Figure 15*). Also called the triangular truss by engineers, the Warren configuration was patented in 1848 by English engineer James C. Warren. Warrens could be and were built with pinned connections, but pinned Warrens were not as well suited to falsework erection than Pratts and were slightly heavier per foot of span. As a result, the Warren was eclipsed by the Pratt throughout the 19th and early 20th centuries.

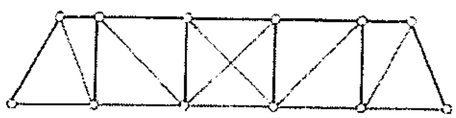

Figure 14. Pratt half-hip truss schematic

It was not until the development of portable field riveters and the attendant proliferation of rigid-connected trusses that the Warren found wider acceptance. Utah's trusses corresponded with those elsewhere in the nation, with pinned Pratt trusses predominating in the years before 1910 and rigid-connected Pratt and Warrens used after 1910. James Burke, who relied on out-of-state fabricators for his superstructures, used Pratt through trusses and Warren ponies in Utah after 1910. And the Midland Bridge Company, which was erecting Pratt trusses elsewhere in the country, erected Warren ponies in the state at the same time.

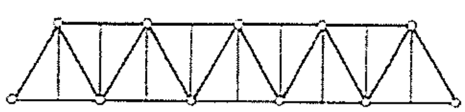

Figure 15. Warren truss schematic

Throughout the 19th and early 20th centuries, virtually all road construction and maintenance in Utah lay under the jurisdiction of individual counties. Owing to the local nature of most traffic, the territorial legislature had historically believed that counties should administer their own road and bridge programs. On January 4, 1896, Utah entered the union as a state. The territorial government was at that time superseded by state government, and the county courts replaced by boards of county commissioners, but road and bridge administration remained essentially unchanged. Between 1896 and the turn of the century, the new state legislature made nominal appropriations–aggregating less than $50,000 per year–for specific, small-scale construction projects. Building roads and bridges still lay within the purview of the counties and municipalities. In 1903 the legislature enacted a law to create a state highway system in which the counties would submit plans for roads and bridges to the state engineer for approval, and the cost of their construction would be borne equally by both county and state. The new law appears to have gone completely unenforced for some reason, however.[28] A similar bill was re-introduced and approved in the 1907 legislative session, but was vetoed by Governor John C. Cutler.

That year, for the first time, a Utah governor acknowledged the changing climate of overland travel brought about by automobiles, urging their regulation by the legislature. "The number of automobiles in use in the State has increased so rapidly during the past two years," Cutler said, "that it seems opportune for a State law regulating their speed to be enacted."[29]

Widespread use of private autos and commercial trucks was only just beginning in Utah, not yet making an impact on the way that roads and bridges were built. It would not take long for people operating cars–and, surprisingly, bicycles–to find their voice in demanding better roads from the government. "Good roads in Utah from now on are to be demanded with a vigor heretofore little known," the *Deseret News* reported in July 1908. "Instead of just an oratorial [sic] sentiment, every county commissioner is to have filed before him a map showing exactly where the bad bumps are and the deep chuck holes, and the poorly built stretches of highway with a boulder bottom and a cobblestone top."[30]

The good roads boosters staged a statewide rally at Lagoon that month, at which Cutler called for "a uniform method of road building [that] would be adopted for the State, thus doing away with the piecemeal efforts of various county commissioners."[31] Cutler was replaced by Governor William Spry that fall; as more good roads conventions were held across the state, however, the message remained the same: Utah must improve its road system dramatically. Spry spoke convincingly to the legislature in 1909:

> Good roads. This subject will be one of the most important brought before you for consideration. It is a problem requiring much thought and attention, and care should be taken that no mistakes are made in the final disposition of the matter. A uniform system of construction with a means of raising special road finances in the various counties should be provided. What is done should be along the lines of stability and thoroughness, having in view a permanency, which unfortunately, has been overlooked in many instances heretofore. A provision should be made requiring competency in those to whom is given the work of improvement. There is no occasion for me to dwell upon the advantages of such improvements to the people of the State, and I heartily recommend your prompt and most earnest consideration of this important subject.[32]

Under pressure from Spry and the various good roads groups, the state legislature finally recognized that highway planning and construction lay at least partly within the province of state government.[33] On March 23, 1909, the legislature established the Utah State Road Commission (USRC). Patterned in part after model legislation distributed that year by the U.S. Office of Public Roads, Utah's law defined the commission as being comprised of the governor, the state treasurer, state engineer, and one member each from the faculties of the University of Utah and the Utah State Agricultural College. The composition of these commissioners–and the fact that theirs was a non-salaried position–was intended to balance the technical and political aspects of highway administration.[34] Despite the legislators' stated intentions otherwise, politics soon took the upper hand and held it to varying degrees for decades to follow.[35]

The Road Commission possessed little real power at its outset; its enabling legislation directed it primarily to establish a system of state trunk roads and design its construction.[36] The agency was funded by a statewide mill levy on real estate, with an initial annual appropriation of $27,000.00: $1,000.00 for each of the 27 counties.[37] This was to be augmented by matching funds from the counties, gifts from individuals or groups and federal moneys from the forest reserves and post roads programs. With such minimal funding, the commission could do little more than encourage and assist the counties in their individual construction efforts.[38]

The counties, to this point, had been building roads on an individual basis, often without regard to the roads in adjacent counties. This tended to create an uneven patchwork of dissimilar routes, making travel difficult for all but a few destinations.[39] One of the first goals of the newly created State Road Commission was the designation of a statewide road system to link the county seats and more populous towns, particularly those communities with no railroad access.[40] A system in only the most general terms, this loosely knit network was initially comprised of existing county roads and city streets.

To identify these roads, the Commission requested that the counties produce maps showing principal routes, towns, watercourses and geographical features. Maps were received from all 27 counties early in 1910, and the Commission at that time made its first tentative foray into the creation of a state highway system. "The Commission has, as far as practicable, endeavored to act in harmony with the desires of the local people," Road Commissioner Richard R. Lyman stated in the agency's first biennial report. "Questions of economy, superior construction, avoidance of grave natural obstacles, lengthening the State road without compensating advantages, have been the cause of whatever divergence of judgment has arisen between the Road Commission and the local people."[41]

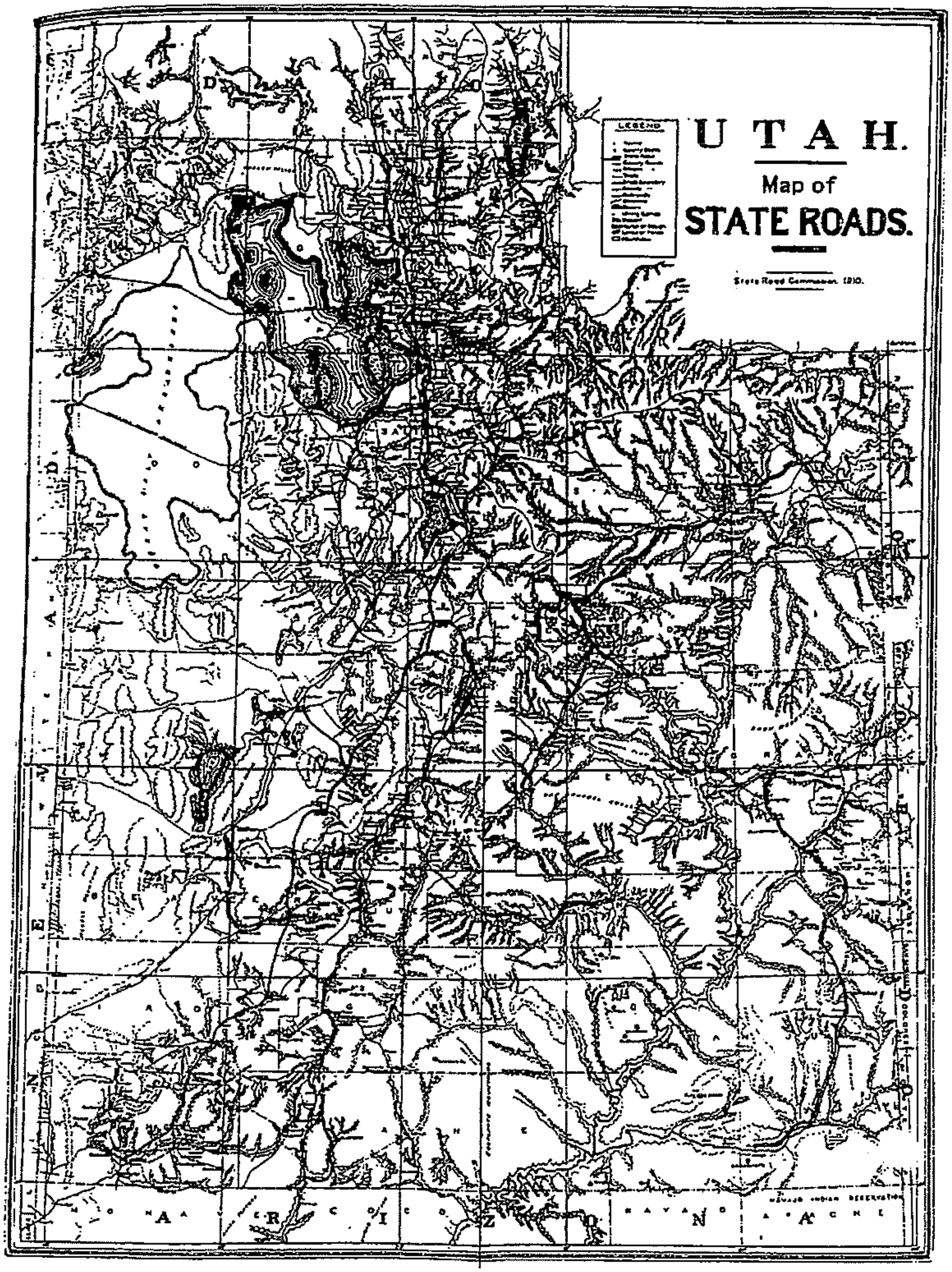

Figure 16. Utah State Road Map, 1910.

The first Utah state road map was published by the Road Commission in 1910 (*See Figure 16*). As indicated by the map, the state routes generally followed paths of least resistance between settlements, in the traditional pattern of colonization and transportation. Most of the routes extended north-south through the Salt Lake Valley, with fingers extending northward to Brigham City and Logan and southward to St. George, Kanab, Richfield and Monticello. A single east-west road crossed the state along its northern end to link Salt Lake City with the agricultural settlements in the Uinta Basin.[42] The state road system graphically reflected Utah's insular nature. No major routes crossed the Great Salt Lake Desert westward into Nevada, and the roads directed south toward Arizona and east toward Colorado and Wyoming petered out before crossing the state line. The only highways to link Utah with bordering states were three routes that extended north to Mormon settlements in Idaho.

The enabling legislation of 1909 provided general guidelines for road and bridge construction, which the Road Commission refined for its own needs. The legislators felt comfortable in specifying 48-and 96-foot roadway widths (which the commission characterized as an unjustifiable extravagance for rural routes), but they deferred to the commission on the more technical matters of bridge design, stating:

> The matter of supplying bridges in any part of the road to be improved should be taken up with the State Road Commissioner in charge of the precinct where road construction is being made. In all cases where money from the State Road Building Fund is to be used in the construction of bridges, it will be necessary that such bridges be constructed either of expanded metal, concrete or steel, depending entirely upon the span and conditions attending each structure.[43]

In addition to its general appropriation to the Road Commission, the legislature in 1909 earmarked $38,000.00 specifically for construction of major bridges at Jensen and Green River.[44] Both spanning the Green River, the Green River and Jensen bridges were two of the largest bridges in the state built during this period. The Jensen Bridge replaced a ferry that had been established in 1885 by Hugh and Albert Snow and William Stewart. Increased ferry traffic had prompted area citizens to petition the Uintah County Commissioners for a permanent bridge at this location. Reviewing the petition and subsequent bids favorably, the commissioners in 1910 authorized the construction of an all-steel bridge

The Jensen Bridge was comprised of three 155-foot Pratt through trusses with pinned connections, extending an overall length, with approaches, of 518 feet (*see Figure 17*). The trusses were supported by steel cylinder piers with upstream cutwaters, founded on driven timber piles. The Midland Bridge Company fabricated and erected the Jensen Bridge, completing the large-scale structure in 1911 for a total cost of $35,000.[45] Midland also designed, fabricated and erected the Green River Bridge, dedicated on December 6, 1910 (*see Fig-*

ure 18). Like the Jensen structure, it was made up of three pin-connected through trusses on cylinder piers. The Green River Bridge used Parker trusses, instead of the Pratts on the Jensen Bridge but was otherwise similar in its length, approach spans and roadway configuration.[46]

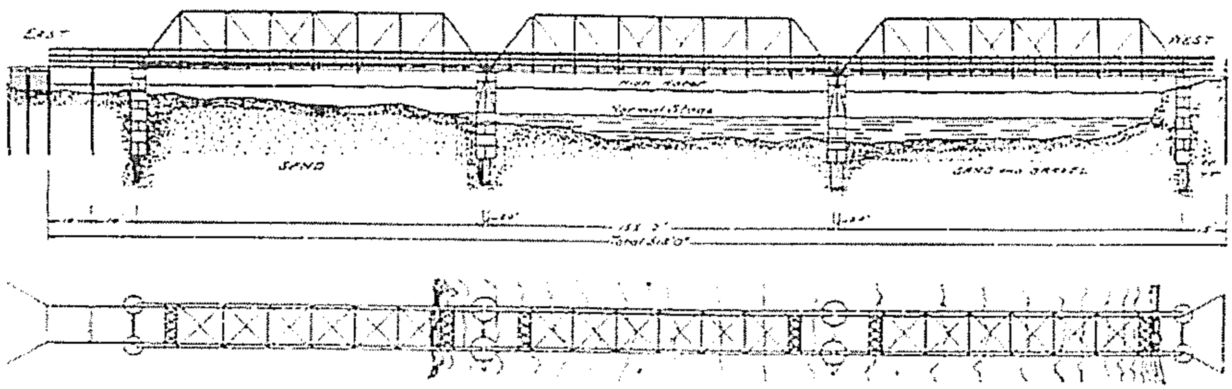

Figure 17 Jensen Bridge, from Utah State Road Commission First Biennial Report, 1909-1910

A third major structure—over the Grand River at Moab—was also built at this time. Like the Jensen and Green River bridges, it replaced a long-standing ferry operation at this location. Citizens around Moab began pressing the county for a new bridge of their own as the Green River structure was nearing completion in late 1910. In response, the Grand County Commissioners ordered soundings made at the site preparatory to building a bridge. In January 1911 Congressman J.P. Miller introduced a bill in the state legislature appropriating $45,000 for the bridge's construction. This amount was reduced to $35,000 in the bill signed by Governor Spry two months later. To fabricate and build the bridge, the county hired the Midland Bridge Company, which completed the structure in January 1912 for a cost of $45,000. The Moab Bridge was dedicated ceremoniously on April 8, 1912, at a barbeque banquet attended by some 1,300 people. Like the Green River Bridge it featured three long-span, pin-connected Parker trusses for an overall length of 602 feet.[47]

The Jensen, Green River and Moab bridges notwithstanding, bridge building during the first two biennia was, with a few notable exceptions, generally limited to short-span timber or crude concrete structures, built empirically using local labor. With a span of 20 feet, the timber span over Denmark Wash (Sevier

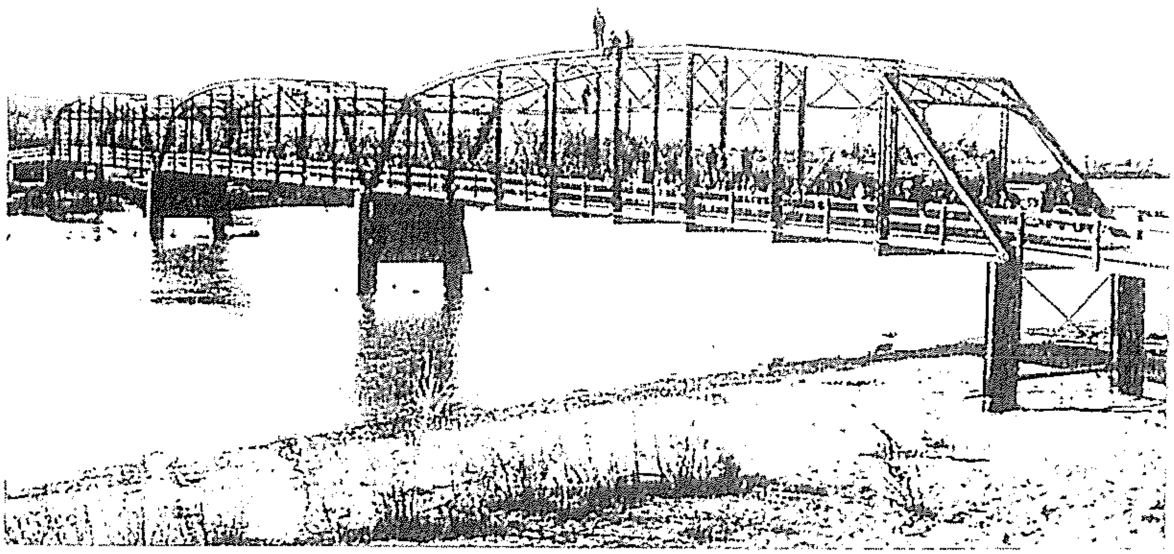

Figure 18 Green River Bridge dedication, 6 December 1910, from Utah State Historical Society

County; 041028C] typified this small-scale construction (*see Figure 19*). The Denmark Wash Bridge was comprised of a single pony truss, supported by concrete mass abutments. Designed by Sevier County Road Commissioner Hans Tuft, the structure employed a kingpost combination truss. Sawn timbers formed the upper and lower chords and the floor beams, stringers and deck; the single midspan hangar on each web was an iron rod, threaded at its ends and bolted to the timber chords. Costing $1,150.00, the Denmark Wash Bridge was built in 1909-1910 by a road district work force. Other structures such as the two-span bridge over the Strawberry River near Theodore and the single-span Marysvale Bridge in Piute County employed timber/iron Howe truss superstructures

During its first two years, the State Road Commission had no engineering staff and no appropriation for engineering expenditures. Despite this, some 125 miles of roads were built by the commission in 1909-10, according to Governor Spry in his message to the state legislature The commission had spent $105,000 during the biennium, approximately half from state sources and half from local "It is gratifying to report increased interest in the good roads movement during the past two years," he said. "State and interstate good roads conventions have been largely attended and I earnestly recommend that the Legislature foster the sentiment for good roads in every way within its power "[48]

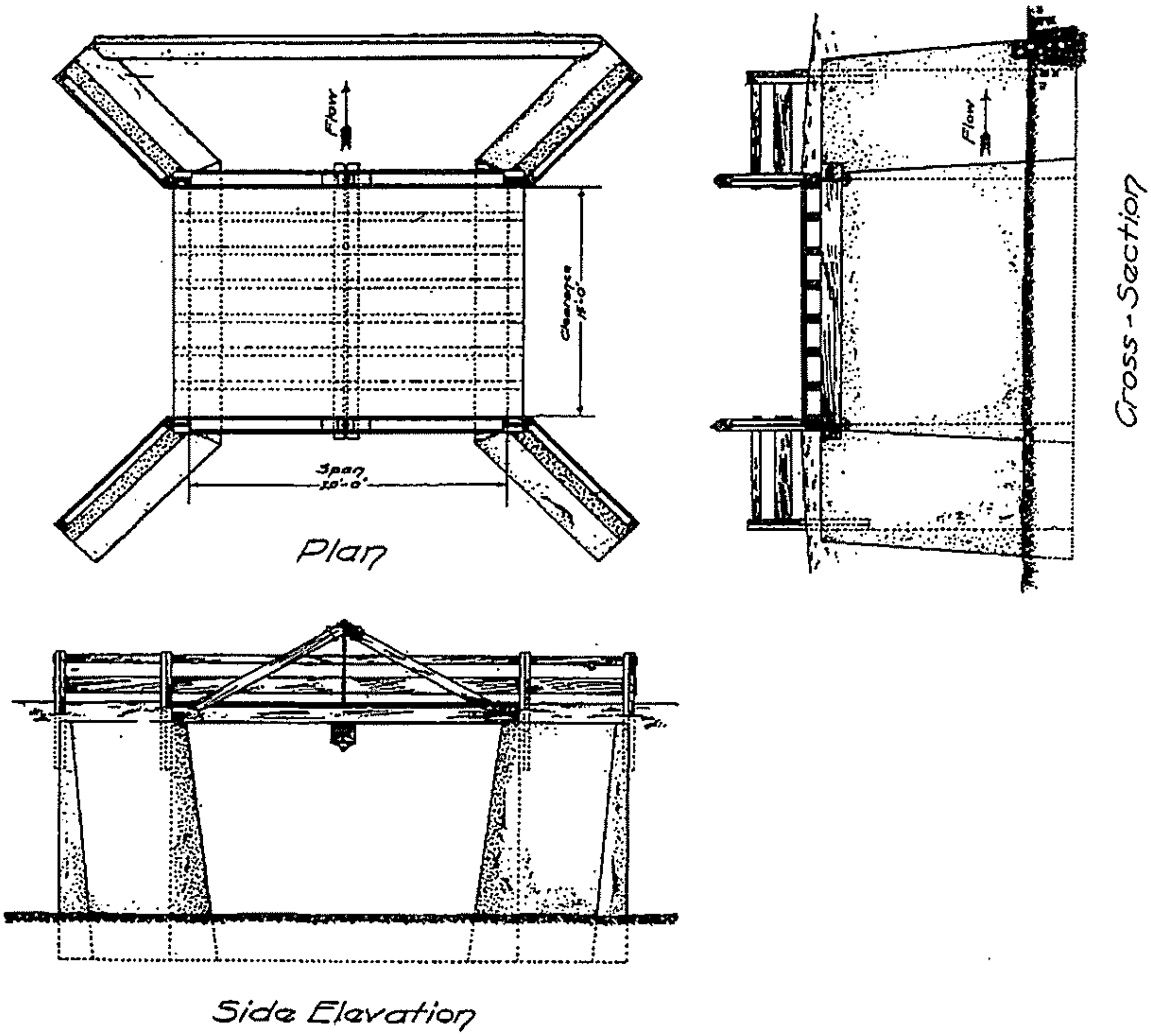

Figure 19. Denmark Wash Bridge, from Utah State Road Commission First Biennial Report, 1909-1910

With the state unable to help with roadway bridge engineering, the counties and cities were left to their own devices. The more prosperous jurisdictions, such as Ogden or Salt Lake City, could afford the salary of a staff engineer or surveyor. Others relied upon consulting engineers or upon the bridge contractors themselves to produce designs. This began to change in 1911, however, as the Road Commission was able to assume a far more active role in road and bridge construction, due to a new mandate and increased funding from the state legislature.

That year the agency's appropriation more than doubled to $60,000, W.D. Beers was hired as Utah's first state road engineer, and administrative offices for the Road Commission were established in the Felt Building in Salt Lake City. As Beers assembled staff to assist with the engineering, drafting and construction supervision, he immediately turned his attention to bridge design. "The organizing of the engineering department of this office," Beers stated in 1912, "was mainly a question of systemizing designs and specifications according to modern engineering practice, and the preparing of standard plans for bridges and culverts that would be suitable for the different conditions and localities in which they might be required. At the same time we had to take care of the engineering that was necessary in connection with the construction work under way."[49]

Under Beers' direction, the state road system was dramatically expanded, and USRC draftsmen began designing permanent bridges for the counties. These structures were engineered, not for cars or horse teams, but rather for the heavy

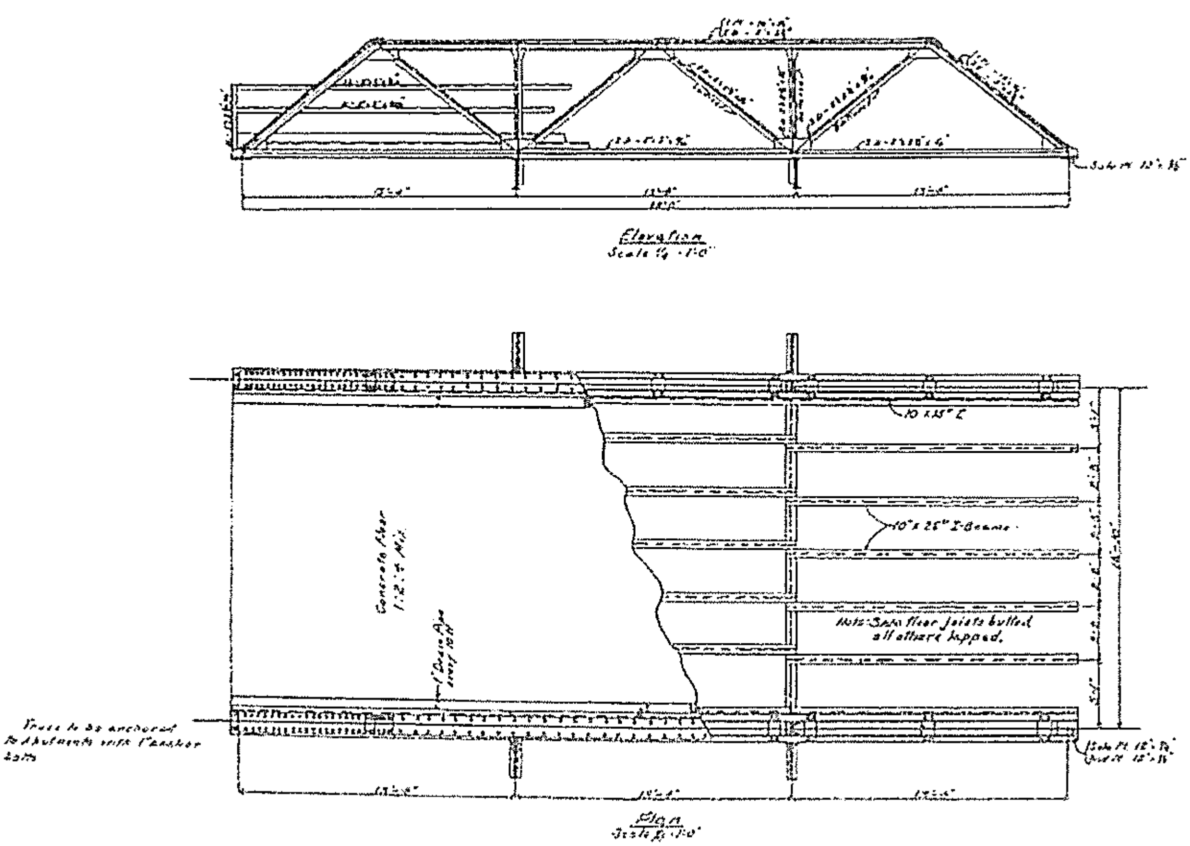

Figure 20 Standard 40-foot Warren pony truss, from USRC Second Biennial Report, 1911-1912

farm and construction equipment that would lumber over them. "In connection with designing of bridges and culverts," Beers stated, "it was deemed advisable to make a study of the rapid increase in the weight of the various road rollers and traction engines in use." He continued:

> With this end in view, communications were addressed to the leading manufacturers of road rollers and traction engines, asking them to submit to us weights and dimensions of their standard makes. This information was then tabulated, and from the results obtained a theoretical loading was adopted which would conform as near as possible to the results of the table. This loading is used for designing all culvert and bridge floors. For the truss system of any bridge the loading of 100 pounds per square foot for spans up to 150 feet in length is used. For all spans above this, a loading of 75 pounds per square foot is used.[57]

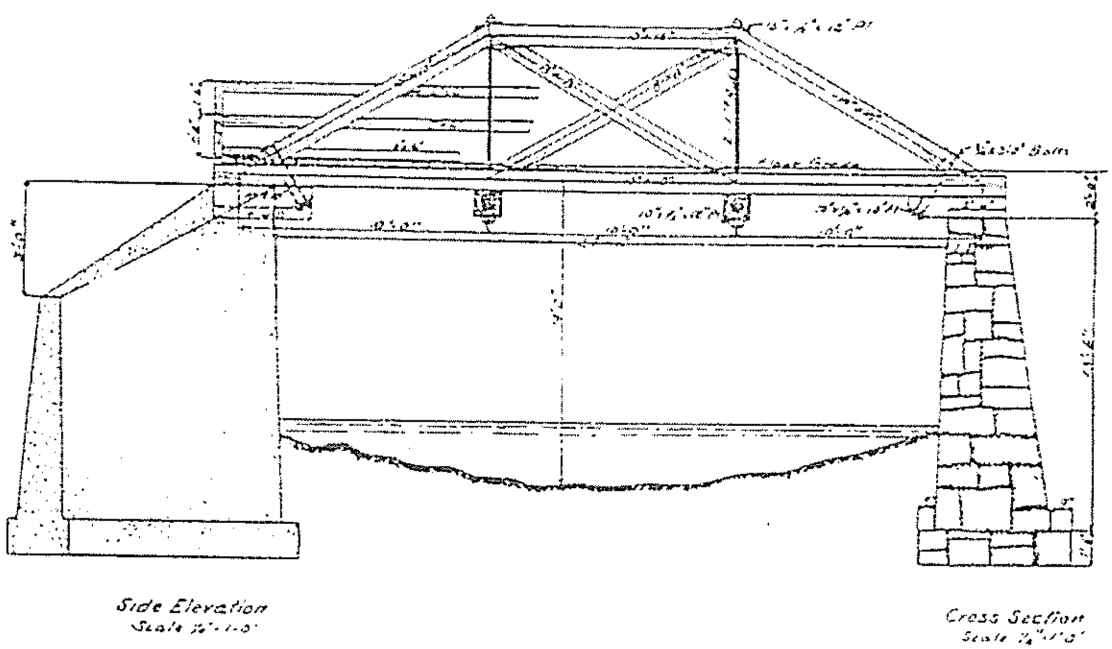

Figure 2[illegible] Virgin River Bridge, from Utah State Road Commission [illegible] Report [illegible]

During Beers' first year, the engineering department delineated plans for six truss bridges ranging in span from 30 to 62 feet (see *Figure 20*), seven steel stringer spans, two short-span concrete slabs, two timber trusses, thirteen timber stringer bridges and two dozen concrete culverts. For the two medium-span timber bridges, Beers used Howe combination trusses supported by stone masonry or concrete abutments. The 30-foot span over the Virgin River in Kane County was a three-panel Howe pony truss, with 8- and 10-inch timbers and 1-inch steel tension rods (*see Figure 21*). The other bridge, a 48-foot span over the North Fork of Dry Gulch at Roosevelt, used a similarly configured, six-panel Howe truss. The stringer and slab bridges were simply configured, with stone masonry or concrete abutments and timber or steel pipe guardrails.

For the six steel trusses, USRC employed industry-standard Warren pony spans with riveted connections. Their configuration closely resembled the Warren trusses fabricated by the Minneapolis Steel and Machinery Company and built at several county-road crossings by Salt Lake City bridge contractor James J. Burke. Although the Road Commission does not give attribution in its reports or drawings, it is possible that USRC engineers used shop drawings from Burke's trusses as the basis for the state's pony truss designs.

The Road Commission redesigned its Warren truss during the 1913-1914 biennium, issuing it as the standard for medium-span crossings (*see Figure 22*). USRC's new truss differed from the earlier design only in detail. The upper chords consisted of typical built-up box beams, the lower chords paired angles with batten plates. Angled gusset plates were used at the connections to join the alternating diagonals with the upper and lower chords, and verticals tied the chords rigidly at the panel points. "The standard steel truss bridge is designed with Warren trusses, having mid-panel hangers," USRC declared in its biennial report. "The trusses are braced laterally at the hanger points, and the floor beams are set on top of the lower chord. The floor consists of a uniform slab or reinforced concrete laid flat on the tops of the I-beam stringers, and having a one-inch crown. The slab has an average thickness of 7 inches. These are the principal features of the designs, and from the standard data devised we can draw up bridge plans in very short notice for all spans ranging from 20 to 100 feet."[51]

The Road Commission designed and built ten Warren pony trusses in the 1913-14 biennium, half of which were based on the newly drafted standard.[52] These ranged in length from the 50-foot span over the Malad River near Plymouth, in Box Elder County, to the 100-foot truss built over Courthouse Wash near Moab, in Grand County. Two of the more noteworthy examples were the 75-foot span over the Price River at Helper [Carbon County; **007032C**] and the 90-foot span over the Price River at Mounds [Emery County; **015021C**]. Both were fabricated from USRC's new standard and erected by James J. Burke in 1914. That year another riveted Warren truss was built over the Beaver River near Adamsville by a private land and water company. Spanning 62 feet, the Adamsville Bridge [Beaver County; **001003C**] was based on the design for the recently completed truss over the Beaver at Milford. The Helper, Mounds and Adamsville bridges all remain in place today in relatively well-preserved condition.[53]

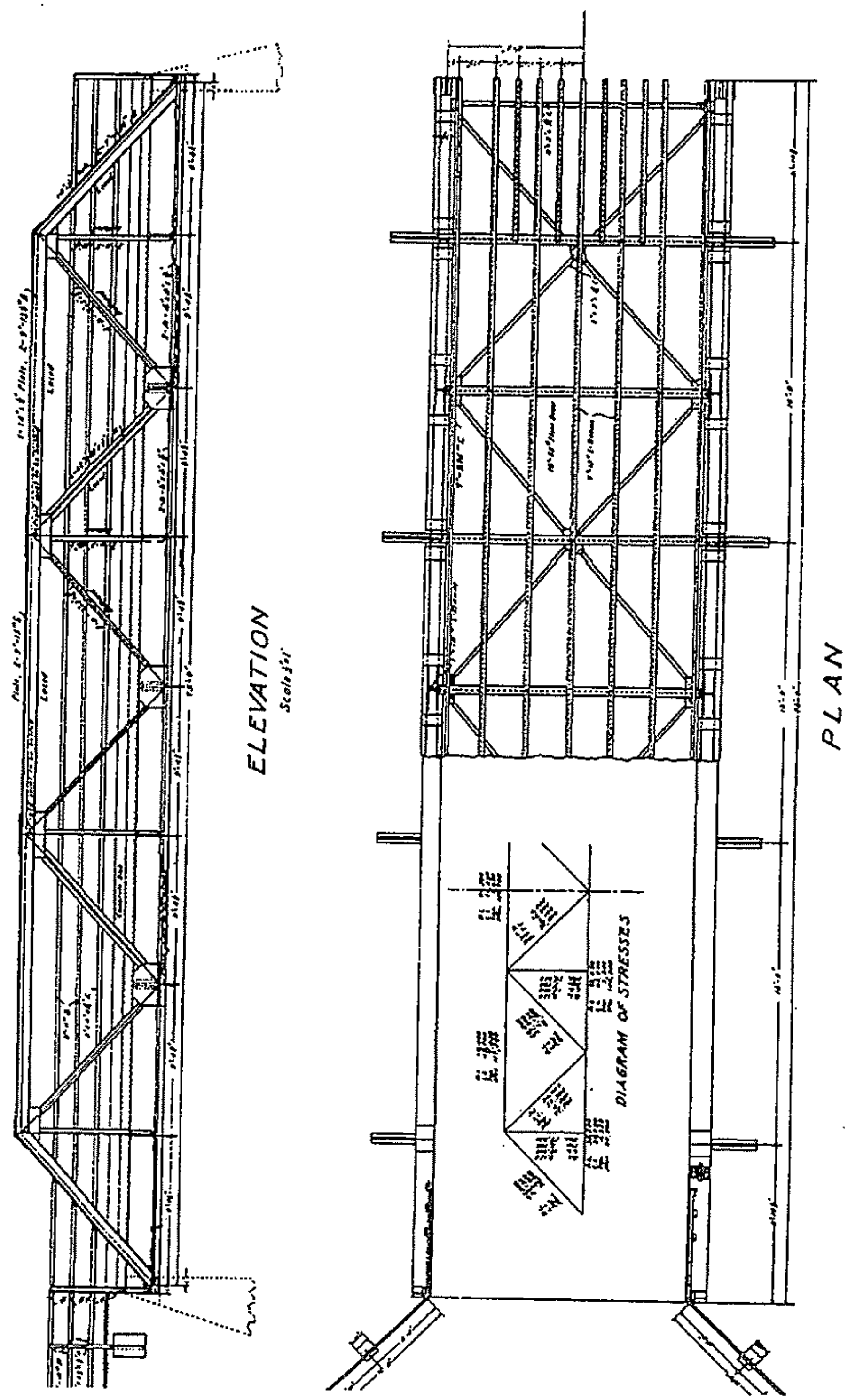

Figure 22. Standard 76-foot Warren pony truss, from USRC Third Biennial Report, 1913-1914.

In addition to the steel trusses, USRC issued standard designs for other structural types. "During the past biennium the engineering department has standardized all bridge designs, and from the standard data, curves devised, several of the standard designs have already been drawn up, and bridges have been constructed from them," USRC reported in 1914. Using the loading curves, USRC engineers calculated comparative costs for concrete slab and girder and steel truss bridges. Slabs were most economical for spans between five and 20 feet (see *Figure 23*); concrete girders between 25 and 40 feet; and steel trusses for crossings requiring spans in excess of 45 feet. These standard, short-span designs proved especially useful, as explained by State Road Engineer E.R. Morgan in 1914:

> On account of the general rough topography of the State, the streams and washes are essentially narrow, but great in number. There are only a very few places in the State where the State Road crosses a stream requiring a span greater than 100 feet, and most of these places have already been provided with bridges. For this reason we have drawn up our present standards to meet all spans up to and including 100 feet. Moreover, as most of the spans that are to be required fall considerably below 100 feet, we have designed all trusses of the Pony type, having no overhead bracing between trusses. In standardizing the details of the various types many improvements have been incorporated to increase the strength and lighten the weights of the bridges, thereby rendering the designs most economical. Standard loadings have been adopted to apply to all types of bridges, and to all locations in the State.[54]

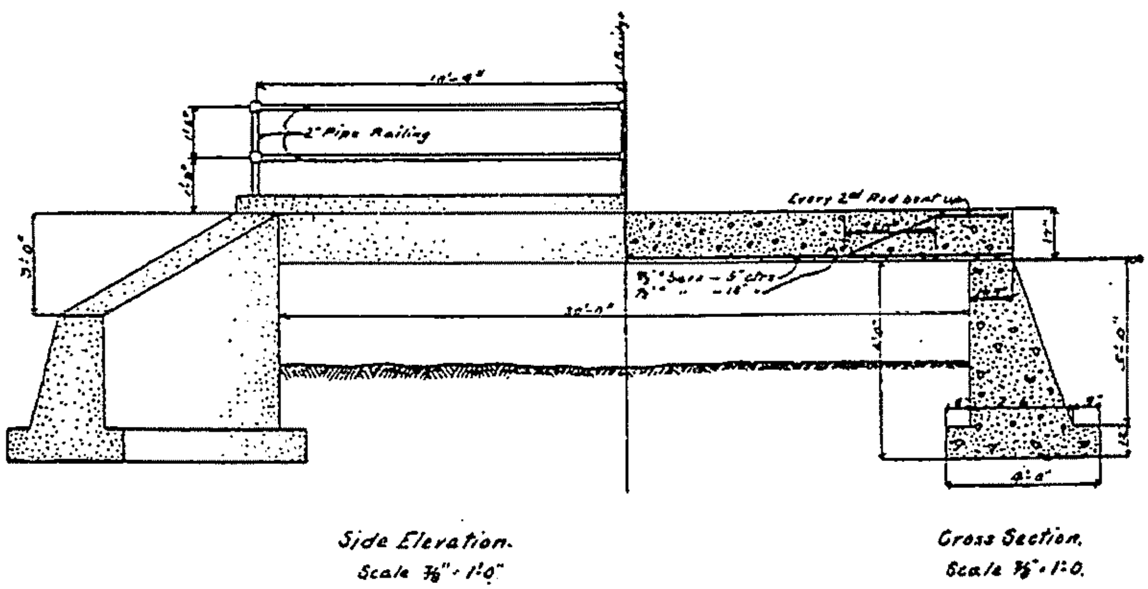

Figure 23. Standard 20-foot concrete slab bridge, from USRC Third Biennial Report, 1913-1914.

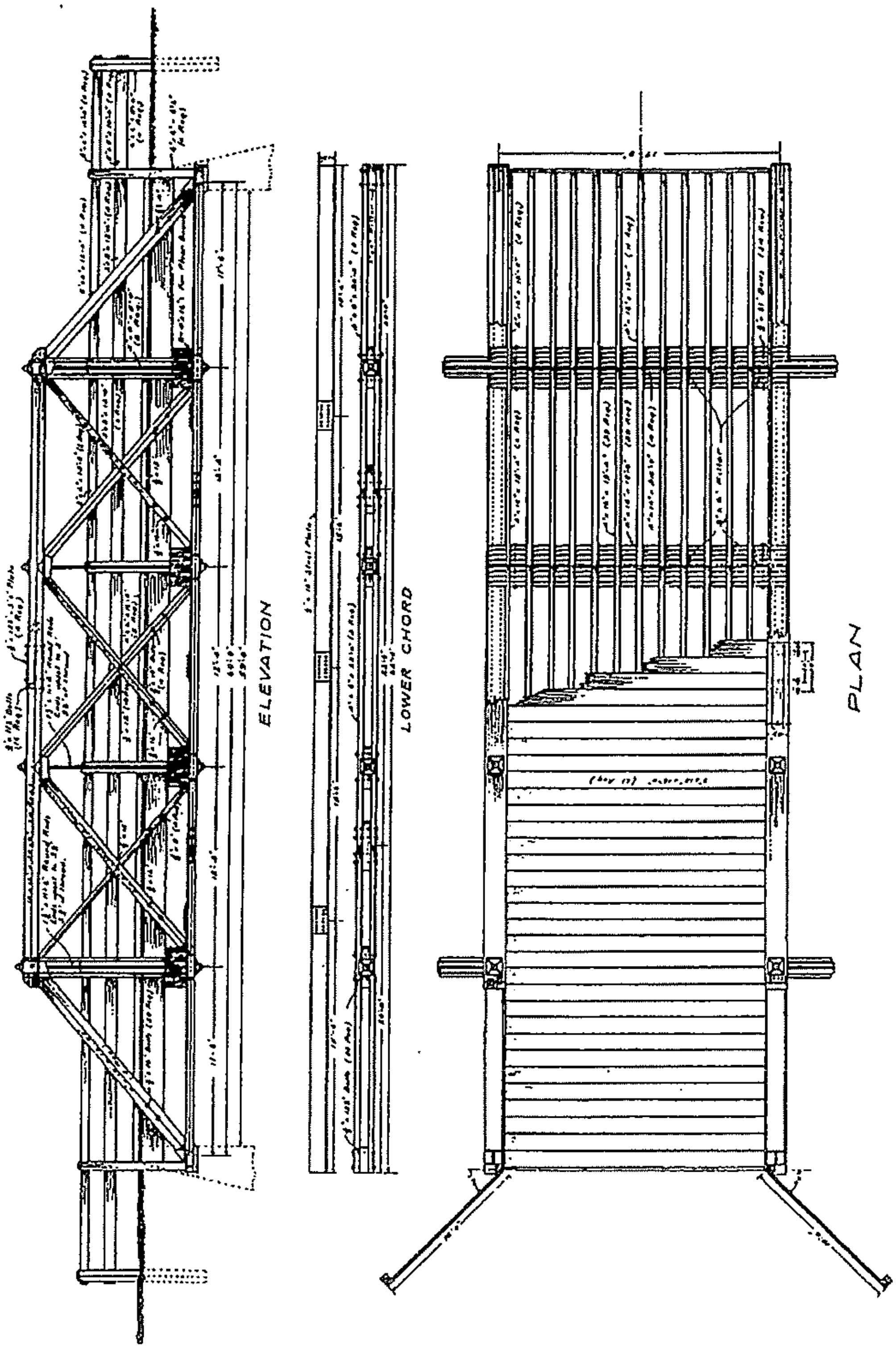

Figure 24. Standard 60-foot Howe pony truss, from USRC Third Biennial Report, 1913-1914.

The reliance on steel and concrete for bridge construction marked a departure from previous practice in Utah, a state in which wood bridge erection had predominated. This emphasis on permanence for bridge superstructures was a distinct philosophical shift from the counties' pragmatic and often short-sighted approach, prompting State Road Commissioner J.W. Jensen to write in 1912:

> It gives me pleasure to state that the day of the wooden bridge or wooden culvert has largely passed in the construction of State roads in Utah. Without exception, in the [northern] district, the culverts and bridges have been made of either steel, stone masonry with cement joints, or concrete, all of which should give service for generations. This will eliminate the necessity of a large percentage of the funds, raised for road construction, being expended for the repair and replacement of perishable structures.[55]

Despite this stated preference for steel and concrete, USRC engineers still maintained plans for wooden/iron truss bridges as part of the agency's repertoire.[56] During the 1913-1914 biennium, the Road Commission built 13 log or timber trusses, ranging in span from 25 to 50 feet.[57] These featured kingpost or Howe web configurations, with timber compression members, steel tension rods with threaded ends and cast iron washers and bearing shoes (*see Figure 24*).[58] The engineers justified the use of wooden spans by their low initial cost and their structural suitability under certain circumstances:

> A [wooden] bridge superstructure constructed in accordance with this design costs a little more than half as much as a corresponding steel-truss or concrete-girder superstructure, and is capable of carrying just as great a load as either of those mentioned. One difference in favor of steel and concrete structures, lies in the fact that their floors are of concrete, which material is preferable to the timber flooring of the wooden structures, and probably the chief point of superiority of the steel or concrete bridge is its permanence. The concrete bridge, well designed and well constructed, should last forever; and the steel bridge will also last indefinitely, as long as it is carefully protected from the rusting action of the atmosphere. The wooden bridge, however, requires less attention than does a steel bridge to prolong its life in certain localities, such as alkali regions.[59]

The promulgation of standard bridge plans marked a watershed in Utah road construction. Whereas counties had for years been dependent upon bridge companies for both the design and construction of medium- and long-span structures, the Road Commission's new designs allowed them to solicit proposals for bridge construction that were truly competitive. Moreover, the standardized designs proved to be stronger and more durable than most of the builders' plans, which often cut structural corners in an effort to economize on material and labor costs. But the standardized designs were limited in their utility. "The use of standard designs for roads, bridges, and culverts, is largely responsible for minimizing the cost of the engineering required in the construction of State Roads," USRC stated in 1914. "Many special designs are demanded, however, to meet the special and peculiar conditions which present themselves in certain places."[60]

Drunkard's Wash in Carbon County was one such "peculiar condition," characterized by a broad, deep gully which remained dry for all but a few days in the year. For this, Road Commission engineers specified a timber pile trestle, comprised of a series of 16-foot wood stringer spans supported above the wash on timber pile bents. They used a similar trestle for the approaches of the 60-foot timber truss over Vega Wash in San Juan County.

In Uinta County, "where concrete and steel are extraordinarily expensive on account of the remoteness from the railroad," the engineers delineated several wooden trusses made of log compression members. "A special design was prepared for the details of this particular type of bridge, so that the logs could be handled in the round, and so that the iron parts could be forged locally, instead of having to be cast and shipped to the bridge site, as is necessary for the standard wood truss bridges." The engineers faced a different problem at the Hobble Creek Bridge site in Utah County. The existing 132-foot structure–comprised of timber stringer spans supported by stone masonry abutments–had by 1913 "become so worn and decayed that it was quite unsafe for travel." The Road Commission used these abutments in building a replacement structure that used concrete deck girder spans.[41]

In addition to its concrete bridge design, the Road Commission had by this time begun to experiment with concrete for road construction as well. The first such concrete paving in the state was reportedly a nine-foot-wide strip placed between Tremonton and Garland in 1912.[42] This was followed by paving on the highway between Ogden and Salt Lake City, placed by convict laborers in 1913, and small-scale concrete road work in Park, Summit and Sanpete counties.[43] "As the building of concrete roads is practically a new departure in the field of highway construction," the Road Commission stated in its 1913-1914 biennial report, "it has required special investigation, study, and design. Most of the methods used in the construction of our concrete roads were taken from the best engineering practice in the more experienced sections of the country."[44]

Perhaps so, but many of the early experiments produced checkered results. And concrete was not universally accepted, as indicated by one newspaper editorial:

> The piece of Portland cement paving, extending from Payson to Spanish Fork and in fact practically every other piece of cement in this state, is showing signs of disintegration. The Payson-Spanish Fork paving is already going to pieces and it has not been in use more than a year. Pavement between Springville and Provo, which is but a couple of years old, is likewise badly in need of repair. The people who are working so hard to force on the public Portland cement paving should see to it that the state gets a better class of work, otherwise, Utah will soon be putting down nothing but the black type of paving. That the bitulithic paving is the better of the two types is now quite generally conceded.[45]

The Road Commission later admitted that inferior materials, improper construction practices and the use of convict labor had been employed in laying the state's first concrete roads, often resulting in their premature failure. Only seven miles of concrete roads were built during this two-year period, but during the 1915-1916 biennium, some 30 miles of concrete roads were constructed, largely by convict labor. By the end of the decade, hard-surfaced roads were underway throughout the state.[66]

Through the mid-1910s, USRC's engineering staff increased annually in correspondence with the agency's budget.[67] By 1914 W.D Beers had been promoted to Road Commissioner, and Hugh C. Lewis was appointed the first State Bridge Engineer, supported by three assistant engineers, a designer and a draftsman.[68] Two years later the staff had increased by four more assistant engineers and several seasonal field engineers. During this time Utah's nascent road system developed and improved as the Road Commission expanded its activities to all levels of construction. Governor Spry, in his 1915 message to the state legislature, outlined Utah's recent road building progress:

> Highway improvement under State supervision has been vigorously prosecuted during the past two years and it is doubtful if any public moneys have ever been expended in Utah that have brought more widespread beneficial results to the taxpayers, than the funds devoted to the State road work. The employment of convict labor on the public highways has passed the experimental stage and is established as one of the most satisfactory and economical steps of our recent advanced legislation. The roads of the State are rapidly becoming permanent structures, and each year as the funds permit, we are reaching after more substantial and enduring road material. There is a growing tendency among the counties to cooperate in road upkeep, a feature whose neglect has in the past made our road construction highly expensive when measured by the life of the road.[69]

In its increasing appropriations for road and bridge construction, the state legislature was responding not only to requests from its Utah constituency but to pressure from outside the state as well. Closely associated with the widespread acceptance of the automobile, which stimulated the building of roads in America, was the "idea for centralized road construction developed from a nationwide 'good roads movement'."[70] The American public began to realize that a more dependable transportation network was needed if they were to take advantage of innovations in travel and business practices. Utahns were also concerned with these issues, in large part due to the profusion of tourists taking to the Western roads in cars and motor coaches. It was inevitable, then, that Utah would begin to feel pressure from outside the state to open itself to automobile traffic.

The Utah State Legislature first acknowledged out-of-state traffic in 1913, when it passed a special appropriation for construction of the Midland Trail through the state. Extending from New York to Los Angeles as one of the country's first transcontinental highways, the Midland Trail had been routed through central and northern Utah. The highway was to enter the state from Colorado east of Cisco, cross the Green River over the existing Green River Bridge, veer northward through Price, Colton and Spanish Fork and pass through Salt Lake City before skirting the northern edge of the Great Salt Lake by way of Brigham City and Snowville, before passing over the Nevada state line.[71]

Like most of the early proto-highways, the Midland Trail was promoted by a national association made up of businessmen, manufacturers, municipalities and transportation boosters that stood to benefit from the automobile traffic that the route would engender. The Midland Trail Association had little money of its own for road construction, instead concentrating on lobbying efforts and relying upon local and state government entities to build and maintain the roads and bridges along the Trail's length.

The Midland Trail was supported in Utah by the influential *Salt Lake Tribune*, which mounted an editorial campaign for the highway's construction early in 1913. The newspaper urged the state legislature to "put the road in such shape as to allow committees of automobile manufacturers who will pay for surfacing the highway to pass from Colorado in automobiles to Salt Lake City."[72] The legislature, for its part, responded by appropriating $50,000 for construction of sections of the road through Utah, with the proviso that the work be completed that summer.

Construction of the highway in Utah commenced in April 1914 east of Snowville in Box Elder County. "The territory passed through was practically all virgin soil, with heavy sage brush growth over most of it," the road commission reported in 1914. "The road was given the proper crown throughout, the greater part being done by means of two gasoline tractors and two road graders. Some portions were more difficult of construction, requiring fills and dugways; also in a few places, heavy rockwork was encountered causing expensive construction."[73] Almost 100 miles of road were constructed in Box Elder County during that first biennium. Along that stretch the road commission built 240 culverts, three concrete bridges and one timber stringer bridge on concrete abutments (see *Figure 25*). "The occasional floods make the culvert requirements very expensive, and it will undoubtedly be very hard to protect the road against the terrific action of these floods."[74] Construction on the highway continued into 1914, encompassing stretches of new road through Price Canyon in Carbon County and from the Green River Bridge east to the Colorado state line in Grand County.

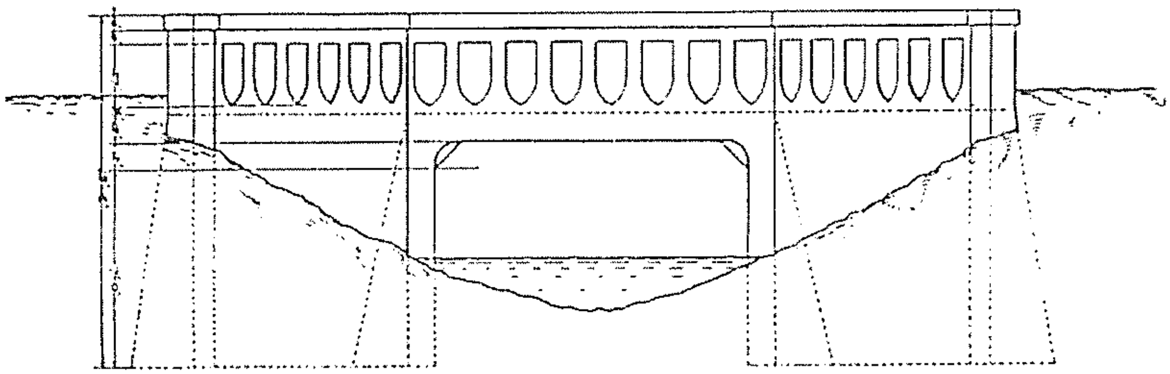

Figure 25. Concrete bridge on Midland Trail, Box Elder County from Utah State Road Commission Third Biennial Report, 1913-1914

The Midland Trail was soon eclipsed nationally by another, more famous route: the Lincoln Highway.[75] The idea for this transcontinental auto route had been formulated by Carl G. Fisher, founder of the Prest-O-Lite headlight company. In 1912 Fisher began boosting what he called the Coast-to-Coast Rock Highway, a continuous line that extended from New York to San Francisco. In September he sponsored a banquet for members of the Indianapolis auto industry to solicit help and money. Fisher wanted $10 million for road-building materials; the labor and machinery, he reasoned, would be provided by cities and counties along the route. The response was immediate. Goodyear president Frank A. Seiberling offered $300,000 that night. Within a month Fisher had $1 million in pledges. The road was soon renamed the Lincoln Highway, and in June 1913 the Lincoln Highway Association was formed to promote it.

One of the first tasks faced by the association was to determine the routing of the highway across America. The responsibility for plotting the highway's route fell on the shoulders of Henry Joy, president of Packard and an early official of the Lincoln Highway Association. Joy studied maps, conducted interviews and traversed the route himself several times in an exhaustive effort to chart the most direct and accessible course across the country. As mapped by Joy, the road generally followed the old Oregon Trail across Nebraska and the old Overland Trail/Union Pacific Railroad across Wyoming (see *Figure 26*). Just across the Utah border it entered Echo Canyon, where it paralleled the UP tracks through the winding gorge, before skipping over into Parleys' canyon and into Salt Lake City. From the city, the highway struck southwest and skirted the south edge of the Great Salt Lake Basin.

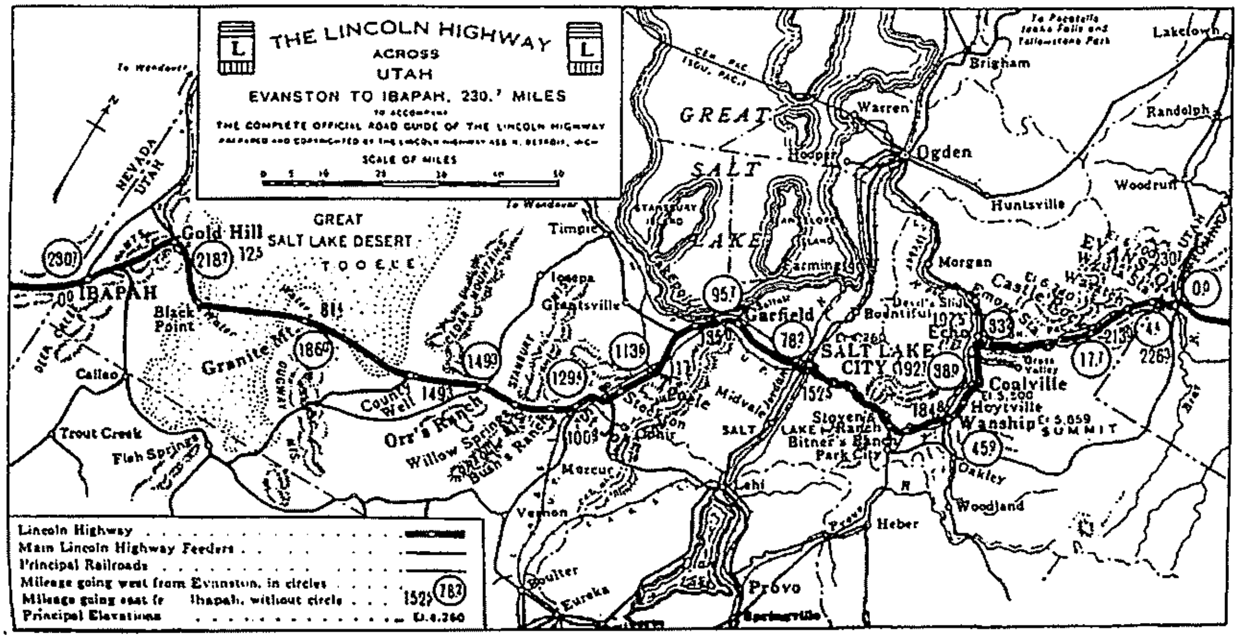

Figure 26. Lincoln Highway Utah segment, from Lincoln Highway Guidebook, 1913

Characterized by Mark Twain in *Roughing It* as "a vast, waveless ocean stricken dead and turned to ashes...," this latter stretch marked the most terrifying part of the route for most cross-country travelers. Joy had chosen a southerly course around the desert because it was fairly direct, it avoided crossing the daunting salt flats directly, and water was available at intervals along the way. Joy's road generally followed the path used earlier by the pony express and overland stage. It meandered around the shoreline of the ancient lakebed, skirting small ridges and mountains and crossing rocky ravines in an effort to avoid long stretches across the desert flats. Still, the Great Salt Lake Desert proved a daunting obstacle to automobilists, as acknowledged by the Lincoln Highway Association in its official road guide in 1916:

> The Lincoln Highway is the main travel road across the state, and when the weather is particularly dry it is liable to be cut up and rough in spots. Extended improvements are contemplated during the coming year and the tourist should encounter no difficulties on the route. In the past, motorists have shown hesitancy about making the trip from Salt Lake City to Ely, Nevada, crossing a small part of the desert, because of the promiscuous circulation of advice as to extra equipment which should be carried. It is advisable to take a thermos bottle of iced water, or a desert water bag and some food in case one is held up with tire or engine trouble, but other than that no extras are needed.[76]

The guide book was perhaps overly optimistic in its mild warning. The meandering, sparsely graded road west of Salt Lake City represented the worst stretch along the entire Lincoln Highway. The long expanse of desert terrain was hard enough on man and machine, but equally hazardous were the intermittent rain storms which could turn a dry stream bed into a raging watercourse. Understandably, very few early bridges were constructed across these dry arroyos or ravines.[77] Many a traveler spent countless hours wrestling his car across steeply inclined ditches only to have his progress wiped out by an unexpected storm.

Most of the major stream crossings had bridges, but even these were washed out periodically by the violent torrents of rain. If a bridge was washed out, travelers had limited options: wait for the water level to subside to a passable level; try to locate another bridge which had survived the storm; or the most popular choice, cross on a railroad bridge.[78] Another widespread problem for desert travelers was the quicksand-like mud that developed when desert sand and rain mingled. Many, like the fateful 1846 Donner-Reed party bound for California, were caught off guard and became hopelessly mired in the treacherous salt flats.[79]

The Midland Trail and Lincoln Highway served to open Utah for the first time to mainstream automobile traffic from outside the state. Utah's open accommodation of these early transcontinental highways proved short-lived, however, as the state legislature soon reverted to its isolationist habits. By 1915 the hurried construction on the Midland Trail was denounced by Governor Spry, who had approved it just two years earlier. "A road was rushed through to take care of those tourists," he stated to the legislature. "And when the major portion of the trail was made passable it was for the accommodation of a few sales agents and demonstrators for certain makes of automobiles..." Spry stressed that road construction in Utah should be primarily for the benefit of Utahns, saying:

> Representations to the contrary, notwithstanding, transcontinental automobile traffic must come through Utah. Our State is on a natural line of travel and we want all of it that we can secure, but it should be provided with good highway accommodation only as our citizens are directly benefitted by expenditures for such roadways.[80]

The legislature was having second thoughts about the Lincoln Highway as well. Soon after designation of the highway's route in 1915, the Lincoln Highway Association began planning an 18-mile embankment–known as the Seiberling Section or Goodyear Cutoff–across the salt flats to eliminate 48 miles of the roughest sections of road. But Spry and the highway commission instead wanted the highway aimed southwest toward Los Angeles and not westward across the salt flats at all. This so-called Arrowhead Trail would entail more miles of highway in the state, carrying tourists close to Zion and Bryce Canyon parks and other scenic attractions in Utah's southwestern corner. Moreover, it would make Salt Lake City, not Ely, the branching-off point for travelers headed toward Los Angeles. When Spry refused to accept the association's proposal for a new route westward, an Ely faction briefly boycotted Salt Lake City businesses.

In 1918 Spry's successor, Simon Bamberger, reluctantly agreed to build the Seiberling Section, but only after the Highway Association donated $125,000 toward its construction. The state proceeded with the construction in a desultory manner over the next year, finally quitting altogether by September 1919 after completing only seven miles.[61] Bamberger first excused the lack of activity by stating rather transparently that the equipment needed repair. He then explained that the state had no money for further roadwork and would proceed at its own pace.[62]

Utah offered as an alternate to the Seiberling Section a route that cut more directly across the open salt flats toward Wendover. Called the Victory Highway, it was little more than a graded path across the salt and mud flats that paralleled the Western Pacific Railroad. Long stretches of the Victory Highway were under water much of the time and frequently impassible. With no settlements or fresh water available along the route, motorists were left to their own devices crossing the desert. Throughout the late 1910s and early 1920s the state ignored protests by the highway association and refused to return the money in what the association characterized as a "rank repudiation of contract which could fairly be stigmatized as dishonorable."[63] Meanwhile, adventurous local voyagers skimmed along the route in "seagoing flivvers", and tourists managed as best they could over the partially completed Seiberling Section, the poorly maintained Victory Highway, the original grade of the Lincoln Highway or the tracks of the Western Pacific, depending on which was most passible at the time.

The State Road Commission was designing many of Utah's bridges by this point, but responsibility for their construction remained largely in the hands of the individual counties and municipalities. Only a handful of these county-built structures remains in place today, none apparently designed by USRC. The longest of these is the Jordan Narrows Bridge (Utah County; **049061C**) over the Jordan River (see *Figure 27*). The Utah County Commissioners solicited competitive proposals for this and another span in August 1914, based on a riveted Pratt through truss design by County Engineer Dan Cavanaugh. The contract to fabricate and erect the bridge was awarded to the Midland Bridge Company of Kansas City. After months of dispute among local citizens over its location, the Jordan Narrows Bridge was finally completed in 1914.[64] It has functioned in place since, with the replacement of its wooden plank floor with corrugated steel as the most

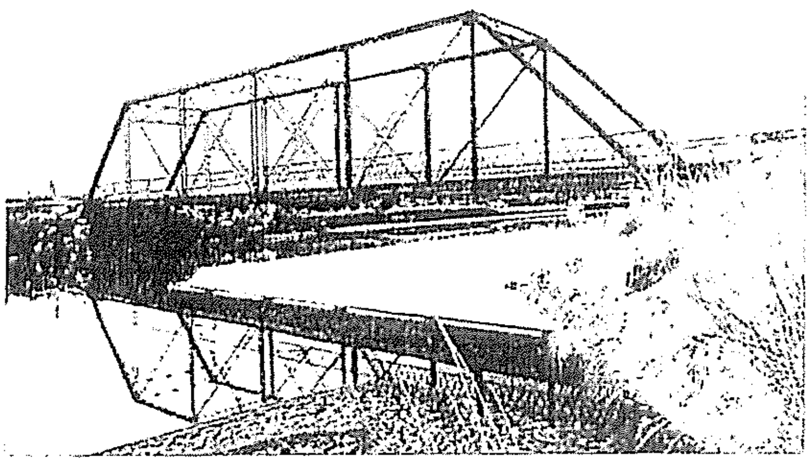

Figure 28 Jordan Narrows Bridge, by Clayton Fraser, 1992

serious alteration. The bridge is currently scheduled for replacement but will be left in place as a pedestrian crossing.

Two other 1910s trusses currently span the Bear River in Rich County [**Rich County; 033006C and 033014C**], both apparently moved from other locations. Fabricated in 1914, the latter span is noteworthy due to its pinned Pratt configuration–one of the last of the pin-connected trusses erected in the state. A single concrete bridge remains from the period: the Little Bear River Bridge [Cache County; **005005D**] located west of Paradise. Designed in the spring of 1915 by the Cache County engineer, this 40-foot concrete deck girder structure was built by local contractor Leroy Hill.[65] It still carries local traffic, in essentially unaltered condition.

Unquestionably the most dramatic bridge dating from the period was the Dewey Bridge in Grand County (see *Figure 29*). Located 25 miles upriver from the town of Moab, the structure spanned the Colorado River at a section that had historically been difficult to ford. Several efforts were made to ensure safe crossing of the river at this site. Samuel King, for example, built a ferry here in the 1890s, which was later operated by Dick Westwood for several years. In 1909 a one-year contract was awarded by the county to George A. Combs for the operation of the Dewey Ferry for twenty dollars a month. But ferry crossing was a cumbersome and sometimes dangerous operation, subject to rapidly changing conditions on the Colorado. Ferry boats occasionally slipped their moorings, often with disastrous results.[66]

Even as they were licensing ferry operators at Dewey, the Grand County Commissioners recognized the need for a permanent bridge over the Colorado River to link Moab with Grand Junction and western Colorado. In 1912 they visited a cable bridge over the Colorado at Cameo, near Grand Junction, to inspect the utility of suspension bridges.[67] Three years later the county engaged the Midland Bridge Company to design, fabricate and erect a similarly configured suspension bridge at Dewey. Midland patterned the structure after a 660-foot suspension bridge it had engineered and built over the Little Colorado River Gorge in Arizona in 1911.[68]

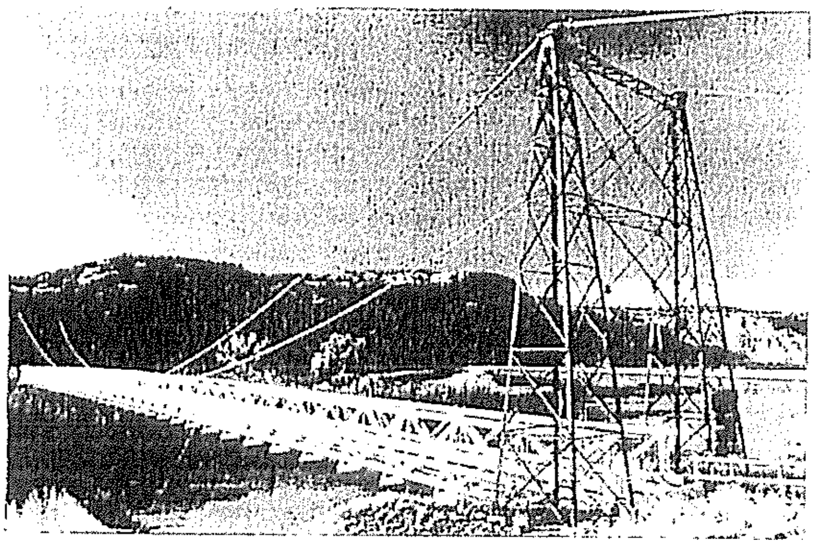

Figure 27 Dewey Bridge, by Clayton Fraser 1986

Construction of the Dewey Bridge began in November 1915 and was completed the following spring. As built, the graceful, lightweight structure spanned 502 feet and had a 10-foot roadway. Its main cables, comprised of seven 1-1/8" galvanized steel lines, were draped over cast steel cradles on riveted steel towers and were anchored by deadmen made of "abt. 40 cubic yards of concrete each." The floor beams, joists and stiffening trusses were all built of Oregon fir. Upon completion, the Dewey Bridge was distinguished as one of Utah's most technologically significant wagon spans.[89]

The first automobile appeared in America in 1893, but its mainstream use in Utah occurred considerably later.[90] The automobile age, coupled with people's higher wages and shorter working hours, provided the impetus for a nation of travelers. Utah's breathtaking natural resources were a popular destination point for many motorists. And tourist traffic meant increased revenue for many areas in the state. As a result counties eventually began to place more emphasis on improved roads leading people to these natural wonders. "These resources have not only been the reason for much road construction," wrote historian Allan Kent Powell, "but have also been the source of funds to pay for maintenance."[91]

Despite this, Utah was slow to embrace the automobile in the 1910s, due largely to the poor condition of its roads. By one report, only 2,600 automobiles operated in the state in 1912, and motor trucks, introduced to Utah in 1905, were still a marginal source of long-range shipping.[92] By 1913, as reported by the Office of Public Roads, Utah contained some 8,320 miles of public roads, of which only 1,018 miles were improved to some degree. In other words, almost 90 percent of the state's road system was still unimproved.[93] Even the major routes were little more than wagon tracks in places, troubled by steep, rocky grades in the mountains and shifting sand and precipitous canyons in the deserts. The bridges ranged widely in structural soundness, some were so suspect that fords were developed along beside them for less adventuresome drivers. By 1916 the situation had improved somewhat as USRC stated in its 1915-1916 biennial report:

> The State Road construction work is rapidly increasing in volume from one biennium to the other, and due to the valuable experience that each year adds to the general experience of the organization, the construction work is improving in quality and efficiency from year to year. Labor saving machinery is being used more than ever before, and the greatest attention possible is rendered in the selection of first class materials for the various kinds of work. Motor tractors are now used instead of horses on all extensive grading projects, and power loading and unloading plants are used on all large surfacing projects. The surveying, designing and inspecting are also maintained to the highest standard possible.[94]

Some 3,440 miles of roads had by then been designated as state routes, of which 404 miles were graded, 56 miles graveled and 35 miles paved with either concrete or asphalt.[95] But even the graded or graveled roads could hardly be considered all-weather routes. "In general the roads were little better than passable during the winter and early spring months, and that chiefly for sleighs and other horse-drawn vehicles," State Road Statistician H.V. Richards reported in 1935. "In the summer the dust on the more heavily travelled roads was extreme, and in the central counties an expensive plan of sprinkling had been inaugurated."[96] With roads and bridges still under control of the individual counties, their maintenance varied widely.

Some 34 bridges and 634 culverts were built on Utah state roads in 1916.[97] The Road Commission was still using the 1913-1914 standards for concrete, steel and wooden bridges for its own structures and distributing standard plans for bridges and culverts to counties and municipalities. These designs received increasing use, as stated by USRC that year: "By far the greatest number of bridges constructed have required special designs for the abutments only, the standard plans being used for the superstructures. These designs have not only saved hundreds of dollars worth of designing but have also saved a tremendous amount of valuable time due to the fact that they are always ready for use."[98]

Among the more noteworthy structures erected during the 1915-1916 biennium were two medium-span trusses over Ash Creek in Washington County and a steel truss over Courthouse Wash near Moab. The two Washington County trusses–one pinned, the other riveted, both ponies–had been originally intended for crossings in Sevier County. They had been delivered but never erected, because they were deemed unsuitable for their sites, and were shipped to Washington County for erection over Ash Creek in 1916.

The Courthouse Wash Bridge presented problems of its own. In order to haul its steel components over the rough road from the railhead at Thompson, the contractor had to shear the rivets from the prefabricated truss webs and re-rivet them on the ground at the bridge site. The 100-foot pony truss was fabricated using a USRC standard design and erected on concrete abutments using gin poles and heavy chain blocks in January-February 1915. One of the abutments began to fail almost immediately "on account of the poor material, poor workmanship and poor weather under which the original abutment had been constructed." It was replaced later that year.[99]

Trusses were used for the crossings requiring relatively long spans, but concrete had by then begun to predominate for small-scale bridge construction, as numerous short-span concrete slab bridges were built over minor washes throughout the state. Two concrete girder spans were built in Beaver County–one in Beaver, the other just north of Minersville–to replace deteriorating wooden structures. Both employed through girder configurations, in which the structural beams were positioned above the roadway. Through girders were used by USRC in the same span range as deck girders, but with the concrete beams incorporated in widened guardrails above the deck, they required less clearance between the deck and the water. Their drawback was that they required somewhat more concrete than deck girders. More important, they could not be subsequently widened as easily as deck girder structures. As a result, they enjoyed only brief popularity with USRC in the mid-1910s.

Single-span through girders were built in 1915-1916 over the West Cache Canal in Cache County and over Dry Creek in Morgan County. The 35-foot span of the Minersville Bridge (see *Figure 30*) was the longest to date for a concrete girder in Utah, until the completion of the 40-foot through girder over the Spanish Fork River in Utah County in 1916. The Spanish Fork River Bridge (Utah County; **049043D**) was designed by USRC at the behest of the Utah County Board of Commissioners and built by contractor Dean Wilcox.[100] Once on the main highway between Spanish Fork and Juab, it still carries local traffic in good condition. The only other concrete structure from this period that is known to be still standing is a through girder over the Sevier River in Sevier Canyon. One of two such bridges built in 1916-1917, it is comprised of two 30-foot spans: the longest overall length to date among USRC's concrete structures (see *Figure 31*).[101] The Sevier Canyon Bridge remains in place in unaltered condition, but it has more recently passed to private ownership following construction of a replacement span.

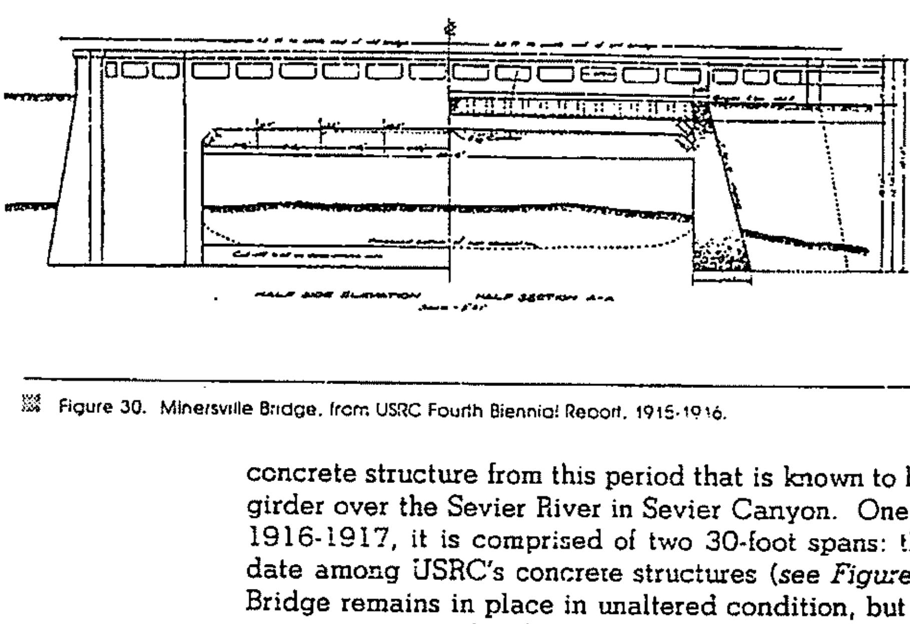

Figure 30. Minersville Bridge, from USRC Fourth Biennial Report, 1915-1916.

The Road Commission was still building timber trusses in the 25-60-foot range, with three Howe spans built in Carbon County, five in Emery County, and one each in Garfield, Kane, San Juan and Uintah counties. In addition, the commission built two hybrid spans in Coal Creek Canyon east of Cedar City. Supported by concrete abutments, these structures featured timber stringers, with iron tension rods blocked beneath, forming an inverted kingpost truss. "This is a most economical form of bridge construction for small spans," USRC reported in 1916. "Care must be given however to provide plenty of clearance for the truss rods, so that they will not catch the floating debris."[102] For short-span crossings in which concrete was impractical, commission engineers typically employed log or timber stringers.

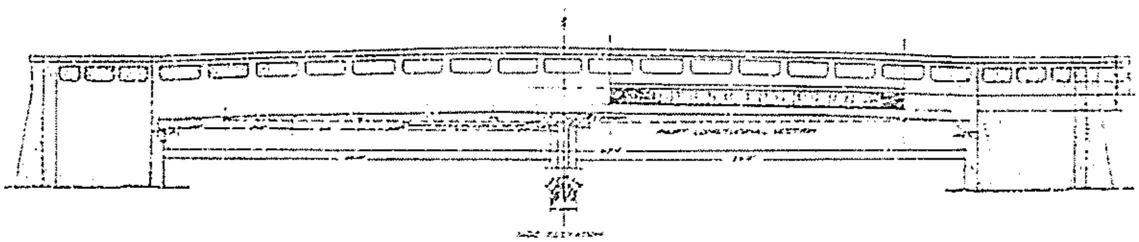

Figure 31 Sevier Canyon Bridge, from USRC Fourth Biennial Report, 1915-1916

The years 1916 1917 represented a watershed in both national and state highway administration. On July 11, 1916, President Woodrow Wilson signed the Federal Aid Highways Act (alternately called the Bankhead Act), ushering in a new level of federal government commitment to road building that swept the states along in its wake. Part of the impetus was from the postal service, which had difficulty delivering mail in many rural areas because of the poor roadway conditions. Business leaders also promoted the legislation, citing the need for more reliable roads to get farm commodities to market. And the massive delays in shipping troops and material by rail during World War I graphically illustrated the need for an alternative overland transportation system. The legislation's goal was to develop an interconnected system of well-built and well-maintained roads throughout the country.

The Act directed the Secretary of Agriculture to distribute highway construction funds and cooperate with the various state highway department in the planning, construction and maintenance of rural post roads. Rural post roads, according to the law, were defined as "any public road over which the United States mails now are or may hereafter be transported," or virtually any road in the United States. The initial-year appropriation for all of the states was $4.8 million, of which Utah received about $57,000.[103] This increased rapidly in subsequent years, so that by the end of the third year $75 million had been appropriated.

To administer the provisions of the Act and disburse the funds, the U.S. Bureau of Public Roads [BPR, predecessor to today's Federal Highways Administration] was formed as an agency under the Department of Agriculture. The Act and subsequent BPR policies carried a plethora of restrictions. Funds could only be used on rural roads, for instance, or on roads in communities with under 2,500 inhabitants. Only projects deemed substantial in character were to be approved for federal aid. Highway funding could not exceed $10,000 per mile, exclusive of bridge costs. Construction would proceed according to state laws, under the direct supervision of the state highway department and subject to the inspection of BPR. And, following completion of the projects, the states were required to maintain the federal aid routes or risk discontinuance of funds for future work.

The Act would have long-reaching affects on Utah's roads and bridges. Not only would it impact the way USRC functioned in its road and bridge administration, it would serve to weave the state into a national web of highways, further opening Utah to the outside. According to Senator Bankhead, the bill's author: "It is essential to the normal development of transportation facilities that the public roads of each State shall be coordinated and correlated with the public roads of the adjoining States."[104] Utah Governor Bamberger made his own priorities clear in a speech to the 1917 legislative session, stating that highway development in Utah was primarily for the benefit of Utahns and "secondarily... transcontinental tourists."[105]

The Utah State Legislature assented to the provisions of the Bankhead Act in May 1917, at the same time restructuring the State Road Commission. The university engineers were out, replaced with the secretary of state and the attorney general. Thus, with the exception of the state engineer, the commission was comprised entirely of elected officials. What little political balance the commission had enjoyed was now gone completely. This was accompanied by a change of administration following the 1916 general elections, in which William Spry and his deputies were replaced by Simon Bamberger and his. With this change came a shift in the administration of the Road Commission as well. State Road Engineer E.R. Morgan was succeeded by Ira R. Browning, and in a domino-like toppling of jobs, about three-fourths of the Road Commission staff was replaced. The State Road Engineer continued to function as before, but Utah was no longer divided into districts with their own commissioners. To match the vastly increased amount of federal funds, the state issued $2 million in highway bonds in 1917, followed by $4 million in 1919 and $1 million in 1921.[106] In addition, the larger cities in the Salt Lake Valley increased their tax levies to step up paving programs within and between their communities.[107]

Utah's Federal Aid Project Number 1 involved construction of a 45-mile stretch of gravel road between Castle Gate and Duchesne; the second project consisted of about ten miles of paved highway between Ogden and Hooper. Federal Aid Project Number 5 in Grand County was the first to involve any substantial bridge construction.[108] Comprising 35 miles of gravel-road improvement of the Midland Trail between Thompson and Moab in 1919-1921, it included construction of seven small-scale steel/concrete bridges and repairs to the existing trusses over Courthouse Wash and the Grand (Colorado) River.[109] One of these small bridges–a 30-foot steel stringer span built over Thompson Wash in 1919 [Grand County; 019020C]–remains in place today and continues to carry local traffic.[110]

The Federal Aid Highway Act also set aside a separate fund for road construction in or adjacent to the National Forests, a boon to many of the Western states which encompassed substantial Forest acreages. Under Section 8 of the Act, Utah was to receive $40,000 annually for ten years, to be matched with state funds. The 43-mile road between Ephraim and Orangeville through the Manti La Sal National Forest was given top priority under the Forest Fund, followed by a 40-mile road between Logan and Garden City (Wasatch National Forest) and a 47-mile segment between Cedar City and Long Valley (Dixie National Forest).[111]

Bolstered by the infusion of federal monies, bridge construction in Utah continued on a steady, if unspectacular, pace through the late 1910s. The Road Commission and the counties during this time concentrated on replacing many of the more deteriorated early timber spans and building new bridges on newly constructed highways or over the expanding network of irrigation ditches in the Salt Lake Valley. USRC engineers were still using and distributing the 1913-1914 standards, although they had by then begun collecting designs from other sources to compare with and incorporate into their own.[112]

World War I interrupted road and bridge construction briefly, with its rationing of strategic materials, but the state was then hampered more by its own fiscal and staff limitations than by war-caused material shortages.[113] The wholesale replacement of USRC personnel in 1917 was exacerbated by the fact that many of the new engineers and road workers had joined the military. This decimated the Road Commission in 1917-1918, as indicated by Ira Browning in 1918:

> Owing to the fact that the new Commission came into office so late in the season of 1917, very little construction work was accomplished during that year, but the time of the State Road Engineer was devoted to ascertaining the needs of the various counties throughout the State preparatory to contemplated extensive improvements during the construction season of 1918.[114]

The 1918 season proved little better, however. That year only fifteen bridges were built on Utah's state roads, almost all with spans under 50 feet.[115] In the absence of state activity, the counties continued with their individual road and bridge projects, typically involving upkeep of short sections of graveled road or construction of small-scale drainage structures. Eventually, road and bridge construction by the state equalled pre-war levels, as the Road Commission began implementation of the federally funded highway program.

Among the more notable bridges erected between 1917 and 1920–many by the counties–were a series of steel and timber spans built in Carbon County; several wooden stringer and truss bridges built in Washington County; a 100-foot-long wooden trestle bridge over Ferron Creek in Emery County; the Lynndyl Bridge, an 83-foot timber bridge in Millard County; an 80-foot timber bridge over the Uintah River in Uintah County; the Oakley Bridge, a 50-foot timber truss in Summit County; a 50-foot steel truss over the San Pitch River in Sanpete County; two 60-foot steel trusses in Sevier County; and series of short-span concrete or timber bridges over canals in Utah and Salt Lake counties [Salt Lake County; OD 448, OE1065, OE1066, OE1067, OE1068]. Additionally, in the wake of increasing traffic tie-ups and fatal accidents, the Road Commission had begun erecting structures to separate highway from railroad traffic by the late 1910s. The Farmington Overhead, a steel girder structure built in Davis County in 1919-1920, was one of Utah's first such grade separations.[116]

The period saw a greater dependence on concrete for bridge construction by the Road Commission, especially after cement shortages had eased by 1919. Although USRC and the counties still used wood extensively for minor crossings and steel trusses for singular long-span crossings, the commission increasingly specified concrete spans–in multiple configurations, if necessary–for many bridge designs.

USRC engineers were even beginning to use concrete for longer-span structures, following a national trend toward large-scale concrete arch construction in the 1910s and early 1920s. This was evidenced by Utah's two most outstanding bridges of the late 1910s: the Logan Bridge and the Provo Bridge. Both were located in urban settings, and both featured filled spandrel arch configurations with steel-bar reinforcing and earth fill. The Provo Bridge was designed in the summer of 1919 by USRC to replace an earlier timber structure over the Provo River (an updated version of the original 1856 span). Built in 1919-1920 by contractor John Holt, the bridge served as a pivotal crossing on the trunk line between Salt Lake City and Provo, one of the most heavily trafficked highways in the state.[117] The Provo Bridge featured two 54-foot elliptical concrete arches, supported by concrete abutments and pier. Its molded concrete balustrade and corbeled arch ring provided a much more architecturally accomplished, classically influenced appearance than had appeared on previous highway spans. The Logan Bridge [Cache County; OD 540], like the Provo Bridge, employed classical ornamentation on its single 70-foot span. Its concrete guardrails were pierced with Gothic arches, and Gothic concrete light standards perched ornamentally at the four corners. Completed in 1919 for a total cost of almost $15,000, it too carried a trunk line highway, in this case the state route through the city of Logan.[115]

Featured prominently in Road Commission publications, the Provo and Logan bridges constituted the most ambitious exercises to date in bridge design by USRC engineers (although they fell far short of other contemporary American arches, some of which spanned more than 300 feet). The bridges were a logical extension of the road commission's preference of concrete for city spans. More solid under traffic and better resistant to flooding, concrete bridges withstood the intense pounding of city traffic more capably than did steel trusses. More importantly, the Provo and Logan bridges represented the first concerted effort by the State Road Commission to coordinate its structures aesthetically with their urban settings. With their gracefully arched profiles and classical details, the two structures contrasted with the starkly utilitarian trusses and girders that had preceded them.

Soon after completion of the two monumental arches, the commission designed and built a handful of more modestly scaled arches over smaller streams. These included a 40-foot span over the Little Bear River at Wellsville (Cache County; 005004D), a 50-foot span over Blacksmith Fork in Cache County, and a 50-foot span over the Spanish Fork River (Utah County; OD 149). In addition, the Salt Lake County engineer designed a 43-foot arch over the Jordan River in Bluffdale (Salt Lake County; OD 24). All built in 1920, these small-scale spans featured elliptical arches with modest concrete detailing.

Used sparingly in the 1910s, the concrete filled spandrel arch never found widespread favor in Utah, because it was soon superseded in the 1920s by more efficient structural types. The concrete through girder had fallen from favor by the early 1920s as well, with the 30-foot span over the Beaver River near Minersville (Beaver County; 001007D), completed in 1921, as perhaps the last of the kind built in Utah. And by 1921 the concrete deck girder had been re-termed the T-beam by the Road Commission, although the two bridge types were structurally indistinguishable.

As America entered into the 1920s, an era of new-found affluence, the majority of states were experiencing an economic boom.[119] This industrial growth was fueled by the automobile industry, which simultaneously helped expand other related industries and expedite the entire economy's growth. "The automobile industry, as a result of the assembly line and other technological advances, grew from a relatively modest size in the years before [World War I] to become one of the most important forces in the nation's economy."[120] Americans bought 1.5 million cars in 1921, 5 million in 1929. The same automobile that had hastened Utah to gain control of its highways had suddenly catapulted all transportation networks into the spotlight.

The dawning automobile age profoundly affected Utah socioeconomic patterns in the 1920s, acting as a stimulus for business and transforming the state's cultural fabric. In-state vehicle registrations passed 100,00 for the first time in 1928. These, and the growing number of out-of-state cars, triggered a proliferation of support industries in Utah, as gas stations, garages, motor courts, cafes, curio shops, auto campgrounds and a variety of other roadside businesses sprang up throughout the state. The ascendence of the motorcar also coincided with the development of a burgeoning new industry: commercial trucking. By the end of the 1920s, the number of commercial vehicles was actually growing faster than the number of passenger cars. The decline of goods transported by railroads and the corresponding expansion of commercial trucking amplified the need for well-constructed, inter-connecting roads.[121]

Beginning with passage of the Federal Highway Act of 1921 and the corresponding state legislation, the 1920s saw a dramatic expansion of state-level highway building in Utah.[122] The Road Commission functioned much in the same capacity as it had in the 1910s, building state roads and bridges and directing the counties in their respective construction programs. The composition of the commission itself was altered by the state legislature in 1921 from five ex-officio members to three members appointed to six-year terms by the governor.[123]

The new commissioners found the going slow at first, however, as the state was experiencing an economic slump in the years following World War I. This was due in large part to diminished demand for farm products and mineral ores. Utah farmers had drastically increased their crop production during the war, creating a post-war surplus that sent local food prices plummeting.[124] The statewide depression retarded highway construction, as reported by USRC in its 1921-1922 biennial report:

> The new Commission found itself greatly hampered in inaugurating a program of road improvement, due to a lack of state funds, and the general inability of the counties to assist in financing needed construction within their borders from causes incidental to the industrial depression. It therefore devoted its energies during the first months of its incumbency primarily to the completion of the unfinished Federal Aid projects for which state funds resulting from the sale of the new bond issue were available, together with additional county funds where these could be secured.[125]

As the decade progressed, highway construction throughout the state gathered momentum. The Road Commission spent $5.4 million during the 1921-1922 biennium for construction and maintenance of state roads and bridges.[126] The amount remained about the same during the 1923-1924 biennium, with $5.6 million distributed over 58 separate federal aid projects constituting almost 250 miles of highway. This included almost 2,500 linear feet of bridges and over a mile of concrete box culverts. Among the more noteworthy structures were the 86-foot concrete bridge over the Malad River near Bear River City; a 100-foot concrete bridge over Seven Mile Wash in Grand County; a 60-foot concrete bridge at Little Mule Shoe in San Juan County; a 63-foot truss over the Provo River in Wasatch County; the Rochester Flat Bridge, a 75-foot concrete structure in Emery County; and the Courthouse Wash Bridge, a 200-foot-long timber trestle in Grand County.[127]

Despite all this work, opening Utah to the outside remained a pernicious obstacle for USRC. "Scant attention has been paid to the roads extending from the central counties to the borders of the State," the commission reported in 1924. "It follows that our gateway roads are generally in a very poor condition. Yet they are the ones tourists must travel in entering and leaving the State, and are, in most instances, roads the improvement of which is essential to the development of the Federal system of highways."[128]

Over the following biennium USRC built 150 miles of Federal Aid highways. Important road segments improved or built at that time involved the road from Spanish Fork to the Colorado line through Price, Green River, Thompsons and Cisco; the road from Salt Lake City to the Wyoming line through Echo and Kimball; the road between Ogden and Uintah; the road from Brigham City to the Idaho line through Tremonton; the road from Levan to the Arizona line through Holden and Fillmore; the Grand Canyon Highway from Richfield to the Arizona line; and several roads in the Uintah Basin. These entailed construction of bridges such as the two spans between Thompson and Moab; the 120-foot truss over the Uintah River at Fort Duchesne, two concrete bridges at Strawberry Point in Morgan County; and numerous small-scale concrete spans.

The Bureau of Public Roads reviewed each of the Federal Aid projects proposed by USRC for compliance with federal design standards. The BPR was also responsible for design and construction of its own roads in Utah's national forests and national parks under the Federal Lands Highway Program. As a part of forest service's Region 4–the Intermountain Region–Utah lay under the jurisdiction of the BPR's Denver office (District 12). During the early 1920s the BPR undertook forest highways such as the Cedar-Long Valley road, a 56-mile segment in the Sevier National Forest; the Ephraim-Orangeville, a 36-mile segment in the Manti Forest; the Heber-Fruitland road, a 50-mile segment in the Uinta Forest; and the Salina-Emery road, a 50-mile segment in the Fish Lake Forest. With much of Utah devoted to federal lands, the BPR's role in developing a statewide highway system was considerable, second only to USRC itself. Like the state road commission, BPR employed standardized designs for its bridges along these routes relying heavily on short-span concrete, steel and timber beam structures.[149] Some of the BPR's most impressive work was undertaken in Zion National Park. This included the Virgin River Bridge completed in 1924 and the 1.1-mile tunnel on the Zion-Mt. Carmel Highway, completed in 1930 at a cost of $2 million.[150]

Meanwhile, the Lincoln Highway controversy continued to simmer, with the Lincoln Highway Association still urging construction of the Seiberling Section and the Utah State Road Commission pushing the Wendover Cutoff. The Lincoln group viewed the Victory Highway (which was routed alongside the Lincoln Highway over much of its length, except the critical Wendover segment) disdainfully as a me-too organization. Although the Victory lacked the political influence and funding of the Lincoln nationally, it enjoyed substantial support from Utah westward. Lincoln Highway president J. Newton Gunn and chief supporter Frank Seiberling pressured BPR officials and Secretary of Agriculture Henry Wallace to designate their route as the federal highway. To bolster their case, they published *A Brief for the Lincoln Highway in Utah and Nevada*, an immaculately documented broadside against the Victory Highway. In response the Bureau of Public Roads' San Francisco office printed its own typewritten "Nevada-Utah Route Study" in October 1922.[151]

Utah's designation of the Wendover Route as the official federal aid highway brought matters to a boil. The battle culminated in May 1923 with a two-day hearing in the Wallace's Washington offices. Gunn, Seiberling and Joy argued for the Lincoln Highway. Utah Governor Charles Maybey, ex-governor Spry and the Utah Road Commission Chief Engineer Howard Means argued for the Victory Highway. After hearing both sides, as well as local factions from Utah, Nevada and California, Wallace announced his choice of the Wendover Cutoff on June 6, 1923. Full-scale, federally funded construction began on the Wendover Cutoff three months later. Contractors completed the first 41-mile segment of the route between Wendover and Knolls in June 1925. They finished the second segment between Knolls and Timpie two months later, and state forces built the remaining 14 miles between Timpie and Grantsville. Calling the Wendover Cutoff "by far the most outstanding road building feature of the biennium," USRC proudly announced its opening in 1925:

> It will, perhaps, be sufficient here to record the success of the undertaking for which failure had been so often predicted and to note that the completed project has been so commended by the engineer and the layman alike as an outstanding triumph of construction. Its completion has surmounted the most uncompromising barrier encountered in the construction of a transcontinental highway

> via Salt Lake City. The stream of traffic already crossing the Wendover road shows the public's appreciation of its advantages. The fear expressed by some that this highway when completed would take tourists too soon and too directly out of the State has not been realized. On the contrary, the road has proved to be a "feeder" for other routes through the State. Reports show that the major part of the traffic is eastbound.[132]

Construction of the Wendover Cutoff marked the most serious defeat ever experienced by Henry Joy and the Lincoln Highway Association. Joy's response to Wallace was bitter:

> We can see neither logic, wisdom nor justice in accepting your suggestion which would now require us to abandon our wise basic principles, to abandon our cooperators in Nevada and Utah, to repudiate our chief supporters, the press and the public. The Association is not seeking new possibilities for routes. All possible connections we have long ago investigated and the establishment of the present Lincoln Way and our large investments thereon were made only after not only we, but the two states of Utah and Nevada, were fully convinced that it was the only right and proper route and the one which would stand as the ultimate one. The present attitude of the state of Utah does not change the existing facts one iota. Utah's present desire to abandon the Lincoln way does not make the Lincoln Way incorrect.[133]

The bridge standards that the Utah State Road Commission had developed and maintained since 1912 were rendered obsolete in 1922 by revisions in design guidelines by the Bureau of Public Roads. This prompted commission engineers to re-draft a new set of standard bridge designs, creating a bottleneck of construction projects that persisted throughout the year.[134] The commission began distributing the new designs in 1923, including plans for steel and timber stringer bridges, steel and timber trusses, concrete T-beams and slabs and steel plate girders. "In general the bridge department wishes to cooperate with the counties in all the varying phases encumbent [sic] upon the economical solution of effectively caring for highway structures," stated Maurice Housecroft, Chief Bridge Draftsman, in the inaugural August 1923 edition of *Utah*

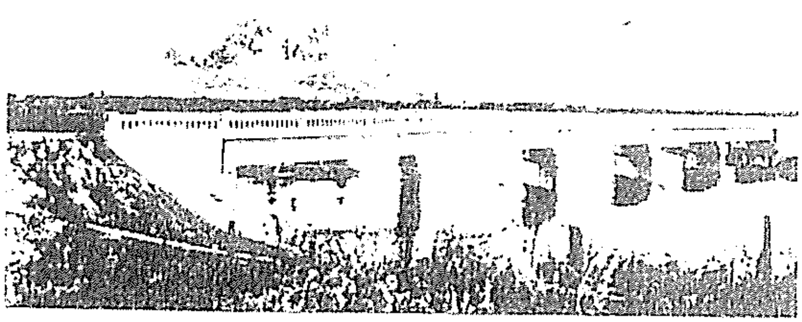

Figure 32 Bear River Bridge, from Special Collections, University of Utah Library

Highways, "whether, in connection with design, construction, repair or strengthening."[135]

The pace of bridge construction set in the early 1920s continued during the 1925-1926 biennium, in which 30 bridges aggregating over 4,000 linear feet were completed or underway.[136] Some of the most noteworthy bridges remaining on Utah's highways were built during the early 1920s. This included the multiple-span structure over the Bear River in Box Elder County, built in 1925-1926 to replace an earlier steel truss. Located on the highway between Bear River and Corinne, this structure was comprised of four T-beam spans with arched haunches, all supported by concrete piers on driven piles (*see Figure 32*). "The Bear river bridge... will be of a T-beam type, plainly and wholly utilitarian in appearance," stated Chief Bridge Draftsman Maurice Housecroft in 1925. "The usual severity of this type of structure have been merged into the graceful appearance of the arch span at very little additional cost."[137] With an overall length of 265 feet, the Bear River Bridge was the longest concrete highway structure built to date in Utah.[138]

Another noteworthy concrete span built in 1925-1926 was the 130-foot concrete arch over Ash Creek in Washington County (*see Figure 33*). Comprised of a single open-spandrel concrete arch, the Ash Creek Bridge marked the state's first use of this intrinsically graceful structural type. But even in its forays into bridge aesthetics, which were by most standards modest, the Road Commission leavened its artistic justifications with considerations of cost. "Added to the beauty of line, permanence and low maintenance cost," Housecroft noted, "is the consideration that due to the peculiarities of the site which the arch will occupy it is from $16,000 to $20,000 cheaper than any type of steel bridge which could be fitted to this crossing."[139]

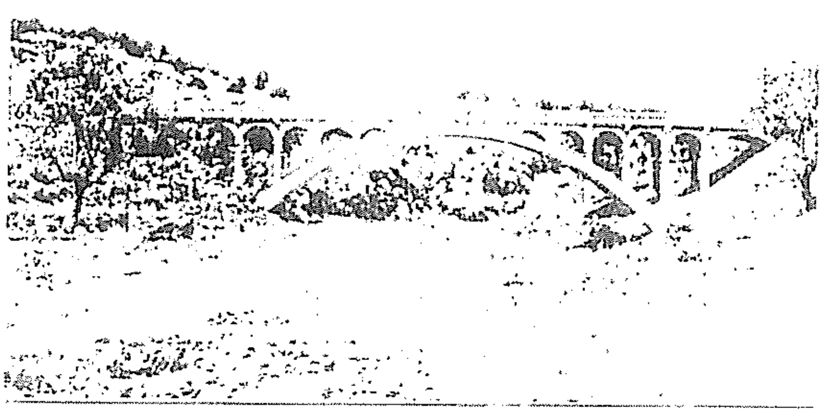

Figure 33 Ash Creek Bridge, from Special Collections, University of Utah Library

As illustrated by these bridges, the steel truss–with its attendant fabrication, erection and maintenance costs, vulnerability to collision damage and limitations on subsequent widening–was falling from favor with USRC engineers in the 1920s. The decade marked the last widespread use of steel trusses in Utah, as the Road Commission eventually dropped trusses in favor of long-span steel or concrete beams. Three of the state's remaining through trusses date from the period: the Woodside Bridge [Emery County; **015006C**], a rigid-connected Pratt through truss with a 100-foot span built in 1923; the Coal Wash Bridge [Carbon County; **007007C**], a 100-foot rigid-connected Warren through truss probably built in 1926; and the Bridgeland Bridge [Duchesne County; **013058C**], a 120-foot, rigid-connected Warren through truss built in 1929 (*see Figure 34*).

These are accompanied by several of the remaining pony trusses, all rigid-connected Warrens: the Hermitage Bridge [Weber County; **057041C**], the Price River Bridge [Carbon County; **007015C**], the Como Springs Bridge [Morgan County; **029002C**], the Sevier River Bridge [Sanpete County; **039003C**], the Santa Clara River Bridge [Washington County; **053002C**], and the Strawberry River Bridge [Duchesne County; **OC 72**].

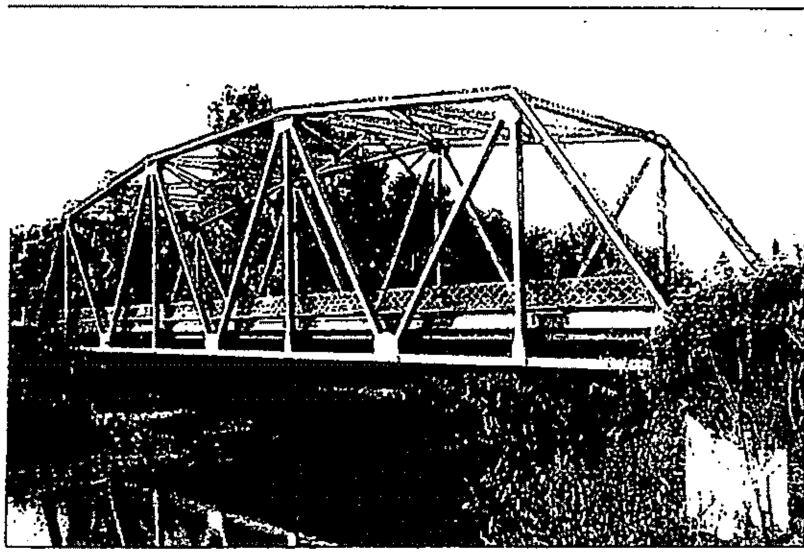

Figure 34. Bridgeland Bridge, by Clayton Fraser, 1992.

The Nunn's Bridge over the Provo River [Utah County; **OD 230**] exemplified USRC's increased reliance on concrete for span lengths that had once been restricted to trusses. Completed in 1926, it was comprised of a single 77-foot concrete T-beam span over the river's channel, supported on a skew by concrete piers and approached on each end by concrete slab spans. "This span is considerably longer than any of its type in this part of the country," USRC stated in its 1925-1926 biennial report. "However, considerable money was saved by a rather unique method of design and construction." This construction involved tapering the girders of the bridge from the bearing points to mid-span to reduce their dead load and tying the slab with keys and stirrups to the girders to help absorb some of the shear stress. "By adopting this type of structure to this particular site several hundred dollars were saved over the cost of a steel span."[140]

Beginning with such structures as the Farmington Overhead in Davis County, the State Road Commission had been concerned with the safety of railroad crossings on state roads. "Railroad grade crossing accidents are few in number compared with the total number of highway accidents," USRC stated in 1928, "but the relative number of deaths resulting from train and auto collisions is very high in comparison with the fatalities occurring from other causes on the highway."[141] USRC had been working steadily throughout the 1920s to replace on-grade crossings by re-routing the highways or construction overheads or subways. In the mid-1920s, for instance, 34 crossings were eliminated by re-routing and 17 by building grade separations. One of the most notable of these early structures was the Riverdale Viaduct in Weber County, completed in October 1924 as a 128-foot steel truss with concrete approaches.[142] The Road Commission typically divided the construction costs equally with the railroads. "The cooperation of the railroads in sharing the costs of grade crossing elimination has been very satisfactory, in consequence of which very good progress has been made."[143]

As the state slowly assumed greater responsibility for road and bridge construction from the individual counties in the 1920s, the complexion of the contracting industry in Utah changed in response. Essentially gone were the design-build contractors of the 1910s, who would provide engineering, fabrication and erection for steel truss and beam bridges. Venerable Salt Lake contractor James Burke was still active during the 1920s, but his competition for bridge construction was shifting from out-of-state specialized bridge builders to general road and bridge contractors operating from within Utah. Contractors Dan Cavanaugh, Strong and Grant, Whitney and Reynolds, Olof Nelson, Strong and Vallandingham, and Christensen, Jacobs and Gardner were all active in Utah in the 1920s.

One of the Utah's most successful road builders, W.W. Clyde, began contracting in 1923, after working eight years as an engineer. The following year he joined in partnership with Jim Sumsion on two road projects–one in Utah and one in Nevada. Clyde mortgaged his house to raise money for the bonds, and he and Sumsion gathered a small workforce with rudimentary equipment to construct the roads. "There was a very small amount of mechanization," Clyde later said of the Nevada undertaking. "We did that job with horses and fresnos and Swede traps and such things as that. We did buy a gravel plant, a makeshift gravel plant, not like they build them today to do the gravel work. We hired trucks, large trucks, to haul the gravel, which had solid tires on." Later on his own, Clyde worked on a variety of highway projects throughout the region, eventually building W.W. Clyde and Company into one of the major contenders in the West.[144]

For Clyde and other road and bridge contractors, the 1920s were a period of relative prosperity, as the state highway system underwent a steady expansion with federal funding. Things changed with the Great Depression, however. According to Clyde, "The financial crash came when Roosevelt went in."[145] But the recession had actually begun during the Hoover administration. The prolonged economic depression that engulfed the United States during the 1930s was symbolically triggered by the stock market crash on October 29, 1929, better known as

"Black Tuesday". Consequently, Americans who found themselves overextended in the stock market, lured by early financial gains and easily obtained credit, were in desperate financial situation. The origins of the crash, however, were rooted in the years before the momentous market failure. Prior to "Black Tuesday", the United States' economy was severely underdiversified because of the previous decade's reliance on the automobile and construction industries.[146]

When both enterprises became sluggish and began laying off workers, no other businesses existed to fill the gap. The domino affect of one institutional failure on the entire nation set the stage for the Great Depression. As a result of the ensuing depression, "There was massive unemployment; over a quarter of the work force is estimated to have been without work in 1932, the worst year of the crisis."[147] The agricultural sector was hit especially hard, because it was still recovering from the post World War I drop in food prices. The Great Depression was so severe and far-reaching that Americans slowly began looking to the federal government for assistance.

Utah, in particular, felt the economic depression deeply, owing to the large number of farmers and miners affected. An excerpt from *Utah's History* demonstrates how difficult life was for miners and the financially strapped state government in Utah:

> In late 1929 thousands of mine workers walked the street of Salt Lake City looking for work. The govemor, George H. Dern, talked tentatively about taking up the employment slack with a $3.25 million accelerated road construction program, but no substaniive action was taken.[148]

State records reveal that per capita income plummeted by more than half between 1929 and 1933; in 1932 fully 36 percent of the population was unemployed.[145] To intensify the challenges Utah faced, the state was hit by two severe droughts, one in 1931 and the second in 1934. Unable to support the countless unemployed, Governor Dern turned to Washington for advice and federal subsidies. President Hoover reciprocated the states governors' pleas for help by creating the Reconstruction Finance Corporation. This entity loaned money to states, which, in turn, Utah Governor Dern used to provide essential goods and services to the many Utahns in need.

Eventually, people nationwide demanded more support from the federal government, electing Franklin D. Roosevelt president in 1932. Roosevelt quickly implemented his plan, called the New Deal, to set in motion relief and recovery programs nationwide. Utah was greatly influenced by the New Deal and two of its major programs, the Civilian Conservation Corps and the Works Progress Administration. Nationwide, the WPA "employed an average of 2.1 million workers at any given moment between 1935 and 1941. The agency was responsible... for... 500,000 miles of roads, and over 100,000 bridges, a portion of which were in Utah. More important, however, the WPA provided incomes to those it employed and helped stimulate the economy in general by increasing the flow of money into it." Thousands of young men in the CCC were dispatched across the nation performing a plethora of labor-intensive tasks, mostly outdoor related.[150]

Of these federal programs, the WPA had the biggest impact on the Utah State Road Commission. "The WPA employed an average of almost 11,000 Utahns annually until 1942, the peak figure being over 17,000 on the eve of the 1936 election. Some $55 million of federal and state-local funds went into projects from building roads, schools, and airports to painting murals on public buildings."[151] These federal assistance programs allowed the state to direct more money and attention to welfare-oriented issues.[152] Ameliorating the area's ability to transport goods efficiently from their origin to market, numerous counties in Utah benefited from the CCC in the form of road construction. Combined, these programs introduced Utah's most productive era of road and bridge building. The influx of federal monies into the state road commission was evenly distributed among the counties, providing work for unemployed Utahns.

In an additional move to create jobs during the Depression, Congress in 1934 passed legislation that allowed federal monies to be used for road and bridge construction within municipalities. The Hayden-Cartwright Act, as this bill was known, permitted state highway commissions throughout the country to build highway bridges and overpasses in cities and towns, which had been heretofore excluded from federal highway aid. The response from the states was startling in its intensity. Utah was one of many states that sought to take advantage of the new funding. The State Road Commission designed numerous small- and medium-scale concrete and steel bridges and overpasses in municipalities around the state. Two well-executed examples of this trend were the Springville Underpasses [Utah County; **OC 139** and **OC 140**], built in 1935. Other noteworthy urban viaducts built during the Depression were the Midvale Underpass [Salt Lake County; **OC 141**], the Farr West Overhead [Weber County; **OD 399**], and the Pleasant Grove Underpass [Utah County; **OC 149**]. Although none of these are structurally adventurous, they are distinguished among Utah's bridges and viaducts for their handsome architectural treatment.

Without question the largest and most impressive of Utah's Depression-era urban viaducts was the Provo Viaduct [Utah County; **OD 413**], which carries State Route 114 over the tracks of the Union Pacific and Denver & Rio Grande Western railroads. Designed by the State Road Commission in 1936, and completed the following year, the Provo Viaduct conveys traffic over 17 spans (15 main spans and two concrete slab approach spans) for a total length of 1,446 feet.

The Provo Viaduct employed cantilevered concrete T-beam spans, much like those used on the Nunn's Bridge. Their 90-foot length are the longest in the state. The imposing overall and span lengths and handsome architectural detailing of the structure distinguish it among the state's remaining highway spans.

The T-beams of the Provo Viaduct, the Yuba Dam Bridge (Juab County; **023005D**) and the Huntington Bridge (Emery County; **OD 458**) (see *Figure 35*) were, other than their long spans and cantilevered construction, similar to those used on numerus smaller-scale bridges throughout the state. During the early 1930s, state road commission engineers developed standard plans for a different structural type that could be used instead of the concrete girder for a range of span lengths. The concrete rigid-frame design, developed in Westchester County, New York, in the early 1920s, became especially popular for federal relief projects across the country during the 1930s. Both picturesque and practical, the flat-arched configuration appealed to proponents of highway beautification and to highway engineers.

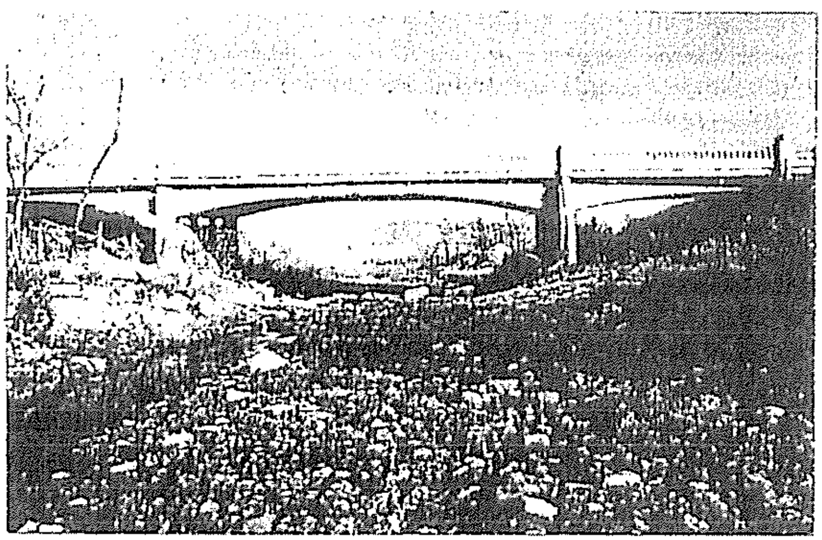

Figure 35 Huntington Bridge, by Clayton Fraser, 1992.

USRC engineers adopted the rigid frame–in both arched and flat configurations–as a state standard for short- and medium-span applications around 1933. Numerous rigid frame bridges were built throughout the state in the 1930s and early 1940s. Most were single-span structures with relatively short lengths, some virtually indistinguishable from box culverts. A few, like the Muddy Creek Bridge (Emery County; **OD 462**) and the Devils Slide Bridge (Morgan County; **029014D**) employed multiple spans. With its three long spans and architectural detailing, the Muddy Creek Bridge stands out as the state's most noteworthy rigid frame bridge still carrying traffic. The Gramercy Avenue Bridge in Ogden (Weber County; **057028D**) was designed in 1937 by City Engineer C.L. Coray, perhaps using state plans, and completed the following year. It is a handsomely proportioned example of local bridge construction during a period in which the state road commission-dominated road and bridge work.

The concrete rigid frame represented one of the few design innovations adopted by USRC during the 1930s. Another bridge type with which USRC experimented was the concrete/timber hybrid bridge (Utah County; OA 342A, OA 342B and

OA 342C), built in 1939. This peculiar structural type combined a concrete slab poured over a laminated timber deck in a singular experiment that was apparently never repeated in the state. Despite these forays in innovative structural engineering, much bridge construction in the state took a decided step backward in an attempt to increase employment on labor-intensive construction projects. Federal funds often came with unusual stipulations: "cement and reinforcing steel shall be unloaded by hand labor methods... Finishing of structural concrete surfaces shall be done by hand rubbing or other labor methods... Carpenter work and form work shall be done by hand labor methods and the use of mechanical saws will not be permitted at the bridge site... All painting shall be done without the use of mechanical equipment."[153] Although later liberalized, Civil Works Administration projects at first permitted not more than ten percent of funds to be used for equipment or materials.

Figure 36. Jensen Bridge, by Clayton Fraser, 1992.

Despite these limitations, a few significant bridges were erected in Utah during the Depression–among them the 1933 Jensen Bridge (Uintah County; **OC 126**) over the Green River, the Hurricane Bridge (Washington County; **OC 158**) built in 1937, and the 1937 San Rafael Bridge (Emery County; **015010A**) spanning the San Rafael River. The Jensen Bridge, built in 1911, had begun experiencing difficulties in 1932, when heavy loads were restricted. In response to the bridge's deteriorating condition, USRC designed a replacement structure and advertised for competitive bids for the construction of a new bridge that year.

Low-bidder at $85,377.00, James J. Burke was awarded the construction contract. A series of private contracts were let for its fabrication and erection. The steel used for its construction was rolled by the Minneapolis Steel and Machinery Division of Minneapolis. Fred Feltch provided the lumber, and J.E. Murray of Springdale furnished the concrete aggregates. After moving the old bridge, which continued to carry traffic while the new structure was built, work commenced on the bridge's sub-structure in the spring of 1933. Despite construction delays, the dedication ceremony took place on November 11, 1933, Armistice Day (*see Figure 36*).[154] The Jensen Bridge formed a pivotal crossing on the coast-to-coast Victory Highway (U.S. 40).

The San Rafael Bridge was one of Utah's most remote and important roadway spans (see *Figure 37*). Situated in the canyonlands southeast of Castle Dale, the structure dated to 1937. The San Rafael Bridge was originally intended to provide a crossing of the San Rafael River for area stockmen hauling supplies to pasturelands below the river. In later years, however, the crossing accommodated a growing number of tourists visiting the Castle Valley region. The bridge was engineered by H.K. Lehmer, K.D. Williams and O.S. Freeman. Reportedly designed for a 100-ton load limit, the structure featured two steel-wire cables supported by tapered concrete towers at both ends. Supervised by Milton P. Greaves, an employee of the Bureau of Land Management, the San Rafael Bridge was built by the Castle Dale Unit of the Civilian Conservation Corps. It was completed in April 1937. On April 24th, some 3,000 people motored to this remote site to attend the dedication ceremonies, presided over by D.D. McKay, regional supervisor of the CCC. As one of Utah's most handsomely sited and proportioned spans, it is historically important for its role in opening the area to visitation and its association with a New Deal relief program.

Figure 37. San Rafael Bridge, by Clayton Fraser, 1992.

The Great Depression in America ended quickly and decisively in the face of worldwide conflict. For two years prior to 1941 President Roosevelt tried to convince the American public to commit themselves to the ongoing war in Europe. His efforts had proven futile, however, owing to the growing isolationist movement in the United States. The surprise Sunday morning Japanese attack on Pearl Harbor in December 1941, though, cemented America's entry into World War II. The Japanese bombers severely crippled American forces in the Pacific, and the calculated attack on the unexpecting naval base provoked enough popular sentiment for the United States to enter the war unhesitantly four days after the bombing.

World War II was distinguished from the Great War because it was a "total war" that would last four long years and influence every aspect of American society.

Total commitment was needed from every industry to ensure the success of the war effort. This comprehensive dedication to victory in Europe and in the south Pacific was eagerly embraced by Utah and its inhabitants. The patriotic movement that prevailed in the 1940s had a profound effect on the state's road commission, which worked under the aegis of the War Department throughout the war. The war department designated 75,000 miles of existing arterial highways in October 1940 as strategically important to national security, forming what it termed the Strategic Network. Of these highways, 1,067 were located in Utah, and the majority of them did not meet military standards. Many roads were deemed too narrow and circuitous, with inadequate shoulders and bridges to meet the higher military criteria. Of the 175 bridges located on the Strategic Network in Utah, some 58 were deemed inadequate to carry military loads and an additional twelve were too narrow.[155] The State Road Commission understood the concomitant positive ramifications of bringing these roads up to war department standards. Not only would more Utahns be employed in the construction industry, but future trade and commerce would eventually benefit from increased road building and improvements, and tourism would eventually profit.[156]

The essential modifications delineated by the commission would necessarily require monetary sacrifice from all concerned. State findings showed that it would cost $30 million to improve the designated roads, a sum twelve times the amount spent in the previous year. An extra $2 million would be needed to build access roads to important military centers located within the state. Obviously, the state road fund was unable to accommodate the war-related expenditures, and ideas were presented which reviewed various methods of procuring essential funds. Federal aid was distributed to each state, with the stipulation that the money was to be used for national defense highways. Consequently, the commission set aside all earlier formulated road plans and concentrated on the road projects specified by the federal government.[157]

Bridges were critical components of the federal defense network of roads and highways. Prior to America's entrance into World War II, the commission's bridge department had built a total of 911 minor spans under 20 feet long, eight spans over twenty feet long, and nine major bridge crossings in the first half of 1940 alone.[158] The road commission, after 1940, erected bridges with national security foremost in the minds of designers and engineers. According to Utah statistics, the state experienced dramatic fluctuations in the amount of bridges built during the 1940s, with great number built near the beginning and end of the war. Most probably the lean years were due to extensive planning and maintenance of the existing road and bridge system. The bridge department was responsible for many facets of road development, including research and design, culverts and ditches, and railroad crossings, in addition to bridge construction and repair. Possibly focusing on these different projects, the bridge department might have made these a priority during the years when few bridges were erected.

Among the bridges built on Utah's strategic highways during World War II were the Weber River Bridge [Weber County; OC 175], the Bear River Bridge [Rich County; OC 205] and the Provo River Bridge [Utah County; OC 199]. All three used a new technology developed in 1939 by USRC engineers. "This structure employs rolled steel beams having the lower flanges severed from the webs at specified locations," USRC explained in its 1939-1940 biennial report. "These severed flanges are then bent to a predetermined curve and the space between the web and the flange in its new position is filled by welding therein a plate comparable in thickness to the beam. This treatment permits of developing increased moments of inertia at points of critical stress without adding additional flange reinforcement. The arching lines of the beams thus treated lend themselves to greatly improved appearances as compared with the use of straight beams with the rather unsightly flange reinforcement."[159] These bridges marked the first use of large-scale welding on highway bridges in Utah, an important milestone in the development of bridge technology in the state.

By the late 1940s the country had largely recovered from the war. To a nation longing for security and prosperity, the suburban home became the ideal. Tract housing developed around Utah's major towns and cities and demanded roads which, when extended, spurred even further development. As in past decades, bridge design continued to evolve as new technologies became available and as structural needs changed. Bridges built for primordial tractors heroically stood the test of heavier vehicles, higher volume and faster traffic, serving long past reasonable expectations. Their increasingly rapid replacement, however, has created an urgent need to recover the survivors. From the humble concrete culverts over irrigation ditches to the complex spans over the Colorado River, these structures provide a tangible bridge between Utah's past and present.

Endnotes

[1]Works Progress Administration Writer's Program for the State of Utah, *Utah: A Guide to the State* (New York: Hastings House Publishers, 1941), 10.

[2]Richard D. Poll, ed., et al., *Utah's History* (Logan: Utah State University Press, 1989), 18.

[3]As quoted in Faun McConkie Tanner, *The Far Country: A Regional History of Moab and LaSal Utah* (Salt Lake City: Olympus Publishing Company, 1976), 33.

[4]Marshall Trimble, *Arizona: A Panoramic History of a Frontier State* (Garden City, New York: Doubleday, 1977), pages 81-82. The Dominguez-Escalante Trail was largely followed by later automobile routes as Utah's highway system developed in the 20th century, forming parts of U.S. 40 (the Victory Highway) and Highway 91 (the Arrowhead Route, later Interstate 15). Allan Kent Powell, ed., *Utah History Encyclopedia* (Salt Lake City: University of Utah Press, 1994), 563-564

[5]As quoted in Powell, *Utah History Encyclopedia*, 490. Like the Dominguez-Escalante route, the old Spanish Trail was generally followed by modern automobile roads, including U.S. Highways 666, 191 and 91 and State Highways 10, 20 and 18.

[6]Ibid.

[7]Gunnison's exploration of Utah proved to be his last. In October 1853, his company was attacked by Pahvant Indians, killing Gunnison and five other men. His railroad survey was completed by Lieutenant Edward Beckwith. Gunnison's massacre was investigated by Colonel Edward Steptoe, who, with a company of 175 soldiers and 150 civilians reached Salt Lake City in August 1854. While in Utah, Steptoe supervised improvements on the Mormon Corridor road in southern Utah–marking some of the first federally sponsored road construction in the territory. As stated by historians Vivian Talbot and Fred Gowans,

> When Utah Territory received a congressional appropriation of $25,000 fore the project, Steptoe had already been assigned to lead a column of reinforcements to California. But because of his experience on previous railroad surveys he was selected in 1854 to carry out this assignment in southern Utah. He began the work amid numerous local requests to locate the road to satisfy various interest groups. Even Brigham Young attempted to get the colonel to spend the appropriation between Salt Lake City and Parowan, rather than on the portion of road for which it was intended. However, using Mormon contractors, Steptoe expended the funds upon the most unsatisfactory stretches of the road between Cedar City and the headwaters of the Santa Clara River. Although the road was opened for travel, the funds were gone before an adequate job could be accomplished.

Powell, 178.

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[8]Howard Stansbury, "A Winter Among the Mormons," *Exploration and Survey of the Valley of the Great Salt Lake of Utah* (London and Philadelphia, 1852), 123

[9]James Vaun Barber, "The History of Highways in Utah from 1847 to 1869" (M.S. Thesis, University of Utah, 1949), 19-20

[10]*Journal History* of the Church of Jesus Christ of Latter-Day Saints, entry of March 1847.

[11]*Journal History*, entry of 28 November 1848.

[12][Utah] *Millennial Star* XI (1851), 342.

[13]*Laws and Ordinances of the State of Deseret* (Salt Lake City, 1919).

[14]Ibid., 91.

[15]Part of the standard ordinances incorporating these cities was the provision "To open, alter, widen, extend, establish, grade, pave, or otherwise improve, and keep in repair, streets, avenues, lanes and alleys; and to establish, erect and keep in repair aqueducts and bridges." Ibid.

[16]*Journal of City Council of Salt Lake City*, Book B, page 60 (6 March 1857).

[17]Ibid., 66 (15 May 1857).

[18]Ibid., 12 June 1857, Book B, 68.

[19]Ezra C. Knowlton, *History of Highway Development in Utah*, 19.

[20]*Deseret News*, 12 March 1862.

[21]*Journal of the City Council of Salt Lake City*, 11 January 1861, Book B, 256, located at Salt Lake County Courthouse, Salt Lake City, Utah.

[22]L.A. Fleming and A.R. Standing, "the Road to Fortune: The Salt Lake Cutoff," *Utah Historical Quarterly* 33 (Summer 1965): 147-172.

[23]Arnold R. Standing, "A Friendly House by a Historic Road: The Hampton-Bigler Home," *Utah Historical Quarterly* 36 (Summer 1968): 233-238.

[24]Ibid.

[25]"Burke Rites Wait Arrival of Sister," *Deseret News*, 10 October 1944; "Burke Requiem to be Conducted Tomorrow," *Deseret News*, 12 October 1944; Salt Lake City directories, 1901-1951.

[26]J.A.L. Waddell, *Bridge Engineering* (London: John Wiley and Sons, 1916), 468.

[27]Ibid., 469.

[28]*Laws of Utah* (1903), "Act providing for the Establishment, Construction and Maintenance of a System of State Highways," approved 23 March 1903.

[29]*Laws of Utah* (1909), "Act Relating to Operating, Running, Managing, Controlling or Driving any Vehicle, Conveyance or Car; or Riding or Driving Any Animals Over or Upon any Public Road, Street, Highway, Public Square or School Ground at a Dangerous Speed, and Providing a Penalty Therefor," approved 20 February 1907. The law termed it a misdemeanor for "such vehicle, conveyance or car to run at a speed sufficient to endanger human life or bodily safety."

[30]"To Smooth Down Bumpy Boulevard," *Deseret News*, 9 July 1908.

[31]As quoted in Knowlton, 127

[32]Ibid., 11.

[33]H.V. Richards, "History of the Utah State Road Commission," *The Utah* (October 1935): 11.

[34]An analysis that accompanied the 1909 bill explained the legislators' intentions for the newly formed Road Commission:

> A law providing for State supervision and State aid in road improvement should be so framed as to remove the administration as far as possible from political influences. It is, therefore, provided in Sections 1 and 2 that a non-paid State highway commission shall be designated, to consist of a professor of civil engineering from a leading university or college of the state, the state geologist and one civilian member to be appointed by the governor. A commission thus constituted would have a majority of its members selected because of their training and engineering ability and without reference to their political affiliations, which would result in a non-partisan and technically competent commission; while the civilian member to be appointed by the governor would bring to the commission the business ability and experience essential to the proper and economic organization and prosecution of the work. At the same time, so long as the governor could only appoint the minority part of the commission, and the same being non-paid, there would be no inducement at any time to make the position one of political preferment.
>
> The actual work of the state highway department should be under the direction of one man possessing technical qualifications, experience and executive ability; but such person should not be called upon to deal directly with the governor or the legislature in regard to matters of appropriation and general policy, as such work would be semi-political, and could be better done by the commission and with less risk of undue influence being brought to bear upon the department. It is, therefore, provided in Section 3 that the state highway commission shall appoint a state highway engineer and shall fix his salary, and that the one so selected shall be a civil engineer and skilled and experienced in road construction and maintenance.

As quoted in Knowlton, 135-136. The eventual composition of the commission was subsequently changed to include two elected positions, a shift which effectively politicized subsequent commission decisions.

[35]It was not until 1921, for instance, that Utah adopted a bipartisan type of road commission.

[36]As reported by the Commission in 1913:

> The State road commission shall select the roads which shall compromise the system of State roads; and shall prepare a map of the roads so designated; shall have charge of the expenditures of State road funds; shall furnish plans, specifications, etc., on application of county commissioners; shall prepare a road manual for the guidance of road officials, keep all records in the office of the State engineer for public inspection; and make a biennial report to the governor. The State road commission shall prepare all plans, specifications and estimates of State roads and may let the work to contract. Engineering machinery, apparatus and the force of the mechanics and instructors operating the same at the University and the Agricultural College of Utah shall assist the State road commission without compensation.

The Official Good Roads Year Book of the United States (Washington, D.C.: American Highway Association, 1913), 133.

[37]The mill levy was augmented from proceeds of sales of motor vehicle licenses, which entailed a one-time cost of $2.00. With 1,334 registered vehicles in the state in 1910, these sales netted the Road Commission only $1,253.00. It would not be until 1915 that annual licensing was enacted, substantially increasing revenues. Richards, 11.

[38]The Commission's budget in its formative years reflected both its tentative beginnings and its subsequent geometric growth. In 1910 the Commission's expenditures aggregated $83,606.00; this more than doubled in 1911 and increased to between $400,000 and $500,000 in the years between 1912 and 1915. In 1916 the Road Commission spent almost $900,000. The agency admitted its supportive role in its Second Biennial Report, stating:

> The Commission is under the greatest obligation to the Commissioners of the several counties for the success that has attended the road building movement. The splendid local response that the State has met supports the contention that the vitality of the law does not rest so much upon the matter of States aid as upon the fact that it provided a means, not practicable before, for the local communities of the State to improve their wagon roads.

Utah State Road Commission, *Second Biennial Report of the State Road Commission to the Governor of Utah*, 1911-12 (Salt Lake City: Arrow Press, 1913), 6-7; Knowlton, 166.

[39]In 1940 State Road Statistician H.V. Richards recounted the abysmal condition of Utah's roads:

> In 1909 there were, outside of the six populous counties in the north-central portion of the state, very few miles of roads which could be classed as improved even with allowance for conditions of thirty years ago. In nearly all other areas within the State, due to the sparse population and limited means, adequate improvement of the highways was a practicable impossibility. In the counties along the State's borders there were, on the east, west and south, no interstate connections other than mere trails and this condition continued, due to legal restrictions in methods of financing, for ten years or more after the creation of the State Road commission.

Utah State Road Commission, *Sixteenth Biennial Report of the State Road Commission*, 1939-40 (Salt Lake City: State of Utah, 1940), 204.

[40]H.V. Richards, "Our Highways," *The Utah* (May 1936).

[41]Utah State Road Commission, *First Biennial Report of the State Road Commission to the Governor of Utah* (Salt Lake City. Tribune Reporter Printing Company, 1911), 6-7.

[42]This road came the closest to providing a border-to-border route across the state. Opposition to the choice of routes prevented the road commission from designating any highway that extended across Utah until 1912. H.V Richards, "History of the State Road Commission of Utah: 1909-1939," *Sixteenth Biennial Report of the State Road Commission* (Salt Lake City: State of Utah, 1940), 206.

[43]*First Biennial Report*, 18

[44]Richards, "History of the State Road Commission of Utah. 1909-1939," 210.

[45]Jonathon C. Horn, "Jensen Bridge: HAER No UT-50," May 1991, *First Biennial Report*, 43; *Second Biennial Report*, 59.

[46]Ibid., 51; *Grand Valley Times*. 16 December 1910; Faun McConkie Tanner, *The Far Country: A Regional History of Moab and La Sal. Utah*, 235

[47]Ibid., 235-238; *Grand Valley Times*, 27 January 1911, 10 March 1911, 16 February 1912, 8 April 1912, Utah State Road Commission, *Third Biennial Report of the State Road Commission: 1913 and 1914* (Salt Lake City: Arrow Press, 1915), 142; Grand County Commissioners' Record, Book A, located at Grand County Courthouse, Moab, Utah.

[48]As quoted in Knowlton, 149

[49]Utah State Road Commission, *Second Biennial Report of the State Road Commission to the Governor of Utah* (Salt Lake City: Arrow Press, 1913), 14. During the 1911-12 biennium, the Road Commission built over 500 miles of road at a cost of $570,000. "In no phase of state constructive work has a deeper interest been taken in the good roads movement as promoted under the provisions of the road laws passed at the last two Legislative sessions," stated Governor Spry in his 1913 message to the legislature. As quoted in Knowlton, 155.

[50]Ibid., 15.

[51]*Third Biennial Report*, pages 29-30.

[52]These trusses were:

100-foot span (new standard) over Court House Wash near Moab, Grand County
90-foot span (new standard) over Price River at Mounds, Emery County
75-foot span (new standard) over Price River at Helper, Carbon County
75-foot span (old standard) over Provo River near Charleston, Wasatch County
75-foot span (old standard) over Provo River between Midway and Helper, Wasatch County
75-foot span (old standard) over Price River in Price Canyon, Carbon County
62-foot span (special skewed design) over Sevier River between Salina and Redmond, Sevier County
62-foot span (old standard) over Beaver River at Milford, Beaver County
60-foot span (special skewed design with sidewalks) over Salina Creek at Salina, Sevier County
50-foot span (new standard) over Malad River near Plymouth, Box Elder County

Third Biennial Report, 30.

[53]Both the Helper and Mounds bridges are currently being replaced. The Helper Bridge will remain in place, incorporated into a pedestrian/bicycle path, while the Mounds Bridge is being relocated to private property to serve as an entrance to a residential development.

[54]*Third Biennial Report*, 29.

[55]*Second Biennial Report*, 35.

[56]The Road Commission described its timber truss standard in its 1913-14 biennial report (page 30):

> The standard wood truss bridge is designed with Howe trusses, having round steel rods as vertical members, and having cast iron washers and bearing shoes. A steel plate is laid on top of the lower-chord timbers to take up the entire lower-chord stress. As in the steel bridge design, the floor beams are laid on top of the lower-chord plates, which position tends to throw the floor level more nearly to-

ward the center of the truss, thereby providing excellent opportunity for bracing the trusses. The trusses are braced laterally at panel points by means of angle irons extending from the upper chord down to the extremities of the floor beams produced. These few features constitute the principal elements of the design of the standard wood truss bridge.

[57]These trusses were

50-foot span over the Strawberry River near Duchesne, Wasatch County
50-foot span over Ashley Creek, Uinta County
50-foot span over Sevier River at Circleville, Piute County
40-foot skewed span over Hamilton Wash, Iron County
40-foot span over Wilberg Wash, Emery County
40-foot span over Cisco Wash, Grand County
40-foot span over Little Grand Wash, Grand County
35-foot span over South Fork of Dry Gulch, south of Roosevelt, Wasatch County
30-foot span over Pack Creek, Grand County
30-foot log span over Snake John Wash, Uinta County
30-foot log span over Powder Springs Wash, Uinta County
30-foot log span over Dry Wash, Uinta County
25-foot span over Five Mile Wash, Emery County

Only one USRC-built timber truss remains in place–the Wilberg Wash Bridge in Emery County. It consists of a 40-foot kingpost log deck truss, supported by concrete abutments. Long closed to vehicular traffic, it is today in deteriorating condition.

[58]"As in the steel bridge design," the road commission stated in its 1913-14 biennial report, "the floor beams are laid on top of the lower-chord plates, which position tends to throw the floor level more nearly toward the center of the truss, thereby providing excellent opportunity for bracing the trusses. The trusses are braced laterally at panel points by means of angle irons extending from the upper chord down to the extremities of the floor beams produced. These few features constitute the principal elements of the design of the standard wood truss bridge." *Third Biennial Report*, 30-31.

[59]*Third Biennial Report*, 30-31

[60]Ibid., 32.

[61]Ibid., 32-34.

[62]H.V. Richards, "Our Highways," 6

[63]There is some dispute regarding the first concrete highway construction in the state, with USRC publications maintaining that the first concrete road was laid between Salt Lake City and Centerville in Davis County or between Tre-

monton and Garland in Box Elder County. The Davis and Box Elder county highways appear to have been built at about the same time in 1912-13, separated by only months in their construction dates. "The Facts on Our Concrete Pavement," *Utah Highways* 1:8 (March 124), 6.

[64]Ibid., 34.

[65]As quoted in "Facts on Our Concrete Pavement," 6.

[66]*Fourth Biennial Report*, 22.

[67]For a thorough discussion of early fiscal matters between the State Road Commission and the individual counties, see Richards, "History of the State Road Commission of Utah: 1909-1939."

[68]The assistant engineers were Levi Muir, A.E. Christensen and W.W. Gardner. Christensen and Gardner later joined to form one of the state's most prolific highway contracting firms.

[69]As quoted in Knowlton, 160.

[70]Powell, *San Juan County*, 230.

[71]Knowlton, 155-156. The Midland Trail was later routed south of the Great Salt Lake, on the same road as the Lincoln Highway between Salt Lake City and Ely, Nevada. There it branched from the Lincoln Highway southward to Los Angeles.

[72]As quoted in Knowlton, 156.

[73]*Third Biennial Report*, 66.

[74]Ibid., 66-67.

[75]Drake Hokanson, author of the definitive history on the Lincoln Highway titled, *The Lincoln Highway: Main Street Across America*, best described how people across the nation felt about the first transcontinental highway: "The Lincoln Highway was an expression of the national desire to bind the country from east to west. It captured the American imagination... in the same fashion as the great westward migration on the Oregon and California trails, the pony express, and the transcontinental railroad had a half century earlier. Along with the motorcar, the Lincoln Highway allowed ordinary citizens... to make their own journey, [and] to express their own transcontinental aspirations..." Drake Hokanson, *The Lincoln Highway: Main Street Across America* (Iowa City: University of Iowa Press, 1988), xvi.

[76]Lincoln Highway Association, *The Complete Official Road Guide of the Lincoln Highway* (Detroit: Lincoln Highway Association, 1916), 129.

[77]One of these early desert bridges–a single-span timber stringer structure built with the original highway in 1918-19–survives intact and is listed in the National Register of Historic Places.

[78]Ibid., 59.

[79]Ibid., 64.

[80]As quoted in Knowlton, 155-156.

[81]Part of this construction included a single-span timber stringer bridge, now on the Dugway Proving Grounds. This small-scale bridge was listed on the National Register in 1975.

[82]Ibid., 78-80; Lincoln Highway Association, *The Lincoln Highway: The Story of a Crusade That Made Transportation History* (New York: Dodd, Mead & Company, 1935), 171-192.

[83]Ibid., 183-184.

[84]Utah County Commission Minute Book G, page 144 (10 September 1914), page 145 (14 September 1914), page 156 (19 October 1914), page 164 (16 November 1914), located at the Utah County Courthouse, Provo, Utah.

[85]Cache County Commission Minute Book I, page 168 (9 June 1915), located at the Cache County Courthouse, Logan, Utah.

[86]Daughters of Utah Pioneers, *Grand Memories* (Daughters of Utah Pioneers, 1972), 143; Phil Fredrickson and Eduardo M. Norat, "Dewey Bridge: National Register of Historic Places Inventory-Nomination Form," 1 April 1984.

[87]*Grand Valley Times*, 12 February 1912.

[88]Built in 1911 under contract with the U.S. Indian Irrigation Service, the Cameron Bridge almost collapsed in 1937 under the weight of a sheep herd. It continued to carry traffic until its replacement in 1959. It was subsequently purchased by the Four Corners Pipeline Company and presently carries a natural gas pipeline in essentially unaltered condition.

[89]Ibid., 144. The Dewey Bridge was listed on the National Register in 1984.

[90]As late as 1915, horses and wagons constituted an important component in state traffic, equal, almost, to the automobile. During a representative

24-hour period at a traffic census stop near the Salt Lake-Davis County line that year, 256 wagons and 37 people on horseback were counted, as compared with 287 automobiles, 79 motorcycles and 7 trucks. This ratio tipped more in favor of horse-drawn vehicles along the more rural stretches of highway in the state. Knowlton, 159.

[91]Allan Kent Powell ed., *San Juan County, Utah: People, Resources, and History* (Salt Lake City: Utah State Historical Society, 1983), 227.

[92]"Forward," *Utah Highways*, 1:1, 3; Powell, *Utah History Encyclopedia*, 566.

[93]*The Official Good Roads Year Book of the United States*, 1913, 396. Even this compared favorably with Wyoming's roads, however, which were reported as over 96 percent unimproved.

[94]Utah State Road Commission, *Fourth Biennial Report*, 1915-16 (Salt Lake City: Arrow Press, 1917), 22.

[95]*Good Roads Year Book* (Washington, D.C.: American Highway Association, 1917), 182-83. These figures, provided by State Road Engineer E.R. Morgan, differ somewhat from Morgan's annual report, which claimed 2,894 miles of state roads, 35 of which were hard-surfaced. H.V. Richards, "Our Highways," 7.

[96]Ibid.

[97]*Good Roads Year Book*, 1917, 182-183.

[98]Utah State Road Commission, *Fourth Biennial Report, State Road Commission, 1915 and 1916* (Salt Lake City: Arrow Press, 1917), page 30.

[99]*Fourth Biennial Report*, 134.

[100]*Fourth Biennial Report*, 293-308; Utah County Commission Minute Book G, page 294 (2 September 1916).

[101]*Fourth Biennial Report*, 251.

[102]Ibid., 144.

[103]Apportioned by a ratio based on area, population and miles of rural post roads, the Act favored the larger, more populous states. Only nine other states–Connecticut, Delaware, Florida, Maine, Maryland, New Hampshire, Rhode Island, Vermont and West Virginia–received lower appropriations than Utah. *Good Roads Year Book*, 1917, 28.

[104]Committee on Post Offices and Post Roads, "Report by Senator Bankhead (Senate Report 250)," in U.S. Senate, *Executive Documents*, 64th Congress, 1st Session, as quoted in *Good Roads Year Book*, 1917, 5.

[105]As quoted in Knowlton, 168.

[106]H.V. Richard, "Our Highways," 7.

[107]Knowlton, 176.

[108]Utah State Road Commission, *Fifth Biennial Report*, 1917-18 (Salt Lake City: F.W. Gardiner Company, 1918), 18, 23; Utah State Road Commission, *Seventh Biennial Report*, 1921-22 (Salt Lake City: Arrow Press, 1922), 82-84. As listed by USRC, the first Federal Aid Projects were:

Project No. 1	Castle Gate to Duchesne	45 miles
Project No. 2	Ogden to Hooper	10 miles
Project No. 4	Price to Emery	63 miles
Project No. 5	Thompson to Moab	35 miles
Project No. 6	Moab to La Sal	24 miles
Project No. 7	La Sal to Monticello	36 miles
Project No. 8	Monticello to Blanding	25 miles
Project No. 9	Delta to Kanosh	55 miles
Project No. 10	Duchesne to Vernal	61 miles

[109]*Fifth Biennial Report*, 80-82.

[110]Utah State Road Commission, *Sixth Biennial Report of the State Road Commission*, 1919-20 (Kaysville, Utah: Inland Printing Company, 1920), 47, 80-82.

[111]*Fifth Biennial Report*, 24-25; Gam Hayward, "Forest Highway System of Utah Approved," *Utah Highways* 1:6 (January 1924), 11.

[112]*Fifth Biennial Report*, 19. In addition, the Road Commission had joined the American Association of State Highway Officials [AASHO], the American Highway Association [AHA], the American Society of Testing Materials [ASTM] and the American Concrete Institute [ACI], all of which, along with the Bureau of Public Roads itself, were distributing materials and design standards for road and bridge construction.

[113]USRC in 1918 stated:

> State Road work has been greatly hampered due to the fact that the United States Highway Council made it necessary to have all projects approved, and unless they believed the project absolutely essential in helping to win the war, they refused to furnish priority orders on shipment of necessary steel and cement. We were also held up to a large extent on account of the Capitol Issues Commit-

tees refusing to allow the sale of Utah State Road Bonds, they of course working in conjunction with the United States Highway Council.

Fifth Biennial Report, 12.

[114]*Fifth Biennial Report*, 12.

[115]*Highways Green Book*, 1920 (Washington, D.C.: American Automobile Association, 1920), 215.

[116]*Sixth Biennial Report*, 67-69.

[117]For more information on the Provo Bridge, see David M. Carroll, "Provo River Bridge," Historic American Engineering Record No. UT-61, May 1991.

[118]*Fifth Biennial Report*, 1917-18, 43; *Sixth Biennial Report*, 1919-20, 60.

[119]While true for the nation as a whole, this was less evident in Utah, which underwent a slump in the years after World War I, owing to diminished demand for farm products and mineral ores. Participating in the wartime effort, Utah farmers had drastically increased their crop production, and consequently, in post-war years this resulted in plummeting food prices. Wayne K. Hinton, *Utah: Unusual Beginning to Unique Present* (Northbridge: Windsor Publications, Inc., 1988), 105.

[120]Allan Brinkley, et al., *American History: A Survey* (New York: McGraw-Hill, Inc., 1991), 700.

[121]WPA, *Guide to the State*, 469.

[122]USRC explained the provisions of the 1921 Congressional legislation that amended the 1916 Federal Highway Act:

> The amendment creating the Seven Per Cent System, approved Nov. 9, 1921, provides that the national Government will cooperate with the States in the building of a system of Federal Highways, which when completed will form a connected system of about 180,000 miles. Seven Per Cent of the total highway mileage of each State is the maximum federal aid mileage, and federal funds may be expended only on the system designated. Not less than three percent of such mileage must be on through routes, that is, roads which form interstate connections. The remainder may be made up of roads which do not reach the state borders but which must connect with the primary system. In Utah at the time of adoption of this amendment the state and county roads totaled 24,050 miles, which allowed us 1,648 miles of federal highway. The system approved to date comprises 1,567 miles laid out over the trunk highways of the State with the excep-

tion of the branch in Washington County to Zion Park and its continuation in the proposed road from the Park to Mount Carmel on the Grand Canyon highway.

Eighth Biennial Report, 34-35.

[125]The first commissioners under the new regime were N.C. Paulson, George D Casto and Ira R. Browning. Browning's former position as State Road Engineer was filled by Howard C. Means. *Seventh Biennial Report*, 9; H.V Richard, "Our Highways" *The Utah*, November 1935.

[124]Hinton, 105.

[125]Utah State Road Commission, *Seventh Biennial Report*, 1921-22 (Salt Lake City: Arrow Press, 1922), 9.

[126]*Seventh Biennial Report*, 7.

[127]Utah State Road Commission, *Eighth Biennial Report of the State Road Commission*, 1923-24 (Salt Lake City: Arrow Press, 1924), 11. All of these bridges have since been demolished.

[128]*Utah State Road Commission, Eighth Biennial Report*, 1923-24 (Salt Lake City: Arrow Press, 1922), 11-12, 22.

[129]U.S. Forest Service, *The History of Engineering in the Forest Service (A Compilation of History and Memoirs, 1905-1989)* (Washington, D.C. Government Printing Office, 1990).

[130]Powell, 651; Angus M. Woodbury, "A History of Southern Utah and its National Parks," *Utah Historical Quarterly* 12:3-4 (July, October 1944), 194-209.

[131]Hokanson, 99, U.S. Bureau of Public Roads, "Nevada-Utah Route Study," 13 October 1922.

[132]*Utah State Road Commission, Ninth Biennial Report*, 1925-26 (Salt Lake City: Arrow Press, 1922), 11-12, 22.

[133]As quoted in Hokanson, 102.

[134]"For most of the projects let in 1922 and for those now in course of preparation this has entailed designing each individual bridge and culvert required," USRC stated in 1923. "As a consequence an unusually large amount of work has been required in this department and since it has been difficult to hire and retain a sufficient number of competent designers at the salaries which the Commission is permitted to pay, the letting of contracts on a number of projects was delayed this year ..." *Seventh Biennial Report*, 20.

[135]Maurice Housecroft, "Standard Bridge and Culvert Designs Available for County Highway Officials Upon Request," *Utah Highways* 1:1 (August 1923), 13.

[136]Utah State Road Commission, *Ninth Biennial Report of the State Road Commission*, 1925-26 (Salt Lake City: State of Utah, 1926), 15.

[137]Maurice Housecroft, "Some Additional Examples of Bridge Design," *Utah Highways* 1:12 (July 1924), 11-12.

[138]*Ninth Biennial Report*, 48.

[139]Housecroft, "Some Additional Examples of Bridge Design," 11-12.

[140]*Tenth Biennial Report*, 77.

[141]*Tenth Biennial Report*, 32.

[142]*Eighth Biennial Report*, 95.

[143]Ibid.

[144]W.W. Clyde, oral interview with Jay M. Haymond, Utah State Historical Society Oral History Program, October 1964.

[145]Ibid.

[146]Brinkley, *American History*, 726.

[147]Ibid., 725.

[148]Poll, *Utah's History*, 484.

[149]Hinton, *Unusual Beginning*, 105.

[150]Brinkley, *American History*, 765.

[151]Poll, *Utah's History*, 489.

[152]Ibid., 525.

[152]As quoted in Nebraska Department of Roads and Irrigation, *Twentieth Biennial Report*, 1933-34, pages 44-46.

[154]Jonathon C. Horn, "Jensen Bridge Historic American Engineering Record No. UT-50" (Alpine Archeological Consultants, Inc., May 1991), 1-9.

[155]*Seventeenth Biennial Report*, 32.

[156]"Highways... and the National Defense," *The Utah* (February 1941): 8-37.

[157]Ibid., 28.

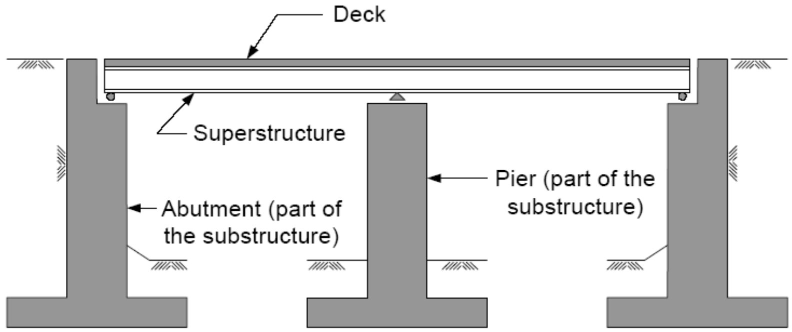
[158]Ibid., 33.

[159]*Seventeenth Biennial Report of the State Road Commission*, 1941-42, pages 7, 39, 146.

Appendix B. Glossary of Basic Bridge Types and Terms

Glossary of Basic Bridge Types and Terms

Abutment – A substructure supporting the ends of a single span or the extreme ends of a multi-span superstructure and, in general, retaining or supporting the approach embankment.



Bridge elements

Source: Michael Baker, Jr., Inc. Bridge Inspector's Reference Manual, Volume 1 (U.S. Department of Transportation, Federal Highway Administration, 2002).

Anchor span – The span that counterbalances and holds in equilibrium the fully cantilevered portion of an adjacent span.

Approach span – A term to designate the spans located on either side of the main span; see main span.

Arc-welding – A process by which steel parts are joined in their molten state, thus creating a metallurgical bond. Intense heat is provided to the joint by an electric arc. See welding.

Arch – The arch bridge, whose basic technology dates back to ancient Rome, is a semi-circular form that can be composed of masonry, brick, steel, timber, or concrete. The structure converts the downward force of its own weight, and of any weight pressing down on top of it, into an outward force along its sides and base. Variations include deck arch and through arch.

Stone arch

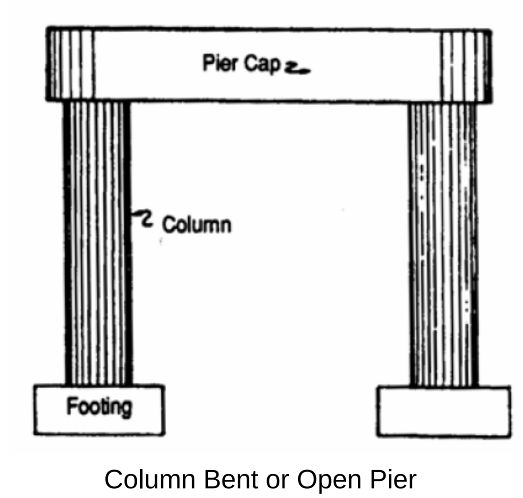
Source: Mead & Hunt, Inc.

Arch rib or ring – The main support element used in open spandrel arch construction; it spans a waterway or roadway and supports the deck.

Beam – A linear structural member designed to span from one support to another. A rigid and horizontal structural element. The earliest beam bridges consisted of wooden planks set on timber or masonry abutments. As material technology advanced, the favored materials for beam bridges became steel and concrete.

Bearing – Mechanical device that transfers the load from the superstructure to the substructure.

Bent – Substructure units made up of two or more columns connected at their tops by a cap or other member holding them in place.



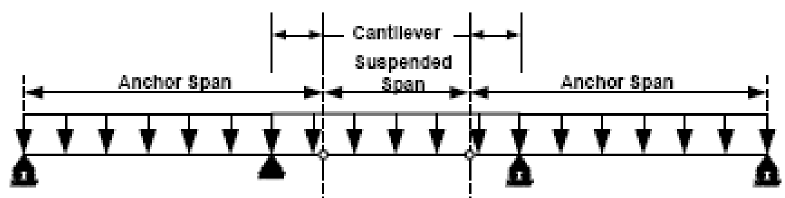
Column Bent or Open Pier
Source: Indiana Department of Transportation, <u>Certified Technician Program Training Manual for Bridge Construction and Deck Repair</u>, 2007.

Bolt connections – A connection system of bolts and nuts, used on trusses and steel beams and girders.

Box culvert – A box culvert is cast-in-place or pre-cast reinforced concrete and has a square or rectangular shape. It is typically located under the embankment to drain water from one side of the road to the other.

Bridge – A structure, including superstructure, deck and supports, erected over a depression or an obstruction such as water, highway, or a railway and having a track or road for carrying traffic or other moving loads. The National Bridge Inventory (NBI) define a bridge as a structure with a length of more than 20 feet (6.1 meters) between abutments or extreme ends of openings for multiple box culverts.

Cantilever – A span that projects beyond a supporting column or wall and is counterbalanced and/or supported at only one end. First applied to truss construction, cantilever and continuous support methods were later applied to other bridge types, including concrete girders and steel I-beams. Cantilevered designs were advantageous because of their adaptability to long spans. The cantilever bridge could be erected without falsework and without obstructing the channel.



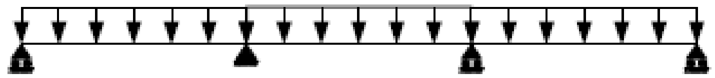
Cantilever Spans
Source: Michael Baker, Jr., Inc. <u>Bridge Inspector's Reference Manual,</u> Volume 1 (U.S. Department of Transportation, Federal Highway Administration, 2002).

Cantilevered spans – A suspended span between adjacent spans with pinned connections, allowing greater lengths to be achieved than could be gained with simple-span construction.

Compression – A type of stress involving pressing together. It tends to shorten a member (the opposite of tension).

Concrete – A building material made of sand and gravel bonded together with Portland cement into a hard, compact substance. Types include unreinforced, reinforced, and prestressed.

Continuous support system – The superstructure spans uninterrupted over one or more intermediate supports. Continuous designs were introduced in the United States in the late 1870s. Although first applied to truss construction, continuous and cantilever support methods were later applied to other bridge types, including concrete girders and steel I-beams. Continuous designs, while statically indeterminate, were advantageous because they required less steel and concrete, produced less deflection, and avoided problematic joints over piers. Railroad engineers were among the first to design continuous structures, especially for overpasses that elevated roadways over railways. Because less steel and concrete were required for beams, continuous structures feature greater vertical clearance and less girth than non-continuous spans.

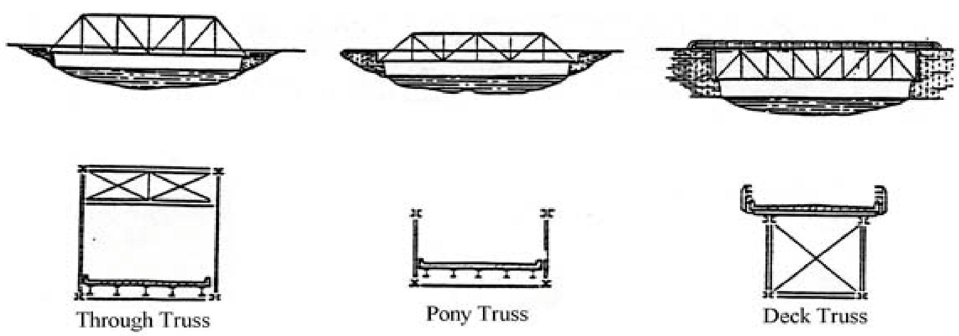


Continuous Spans

Source: Michael Baker, Jr., Inc. Bridge Inspector's Reference Manual, Volume 1 (U.S. Department of Transportation, Federal Highway Administration, 2002).

Culvert – A short span that carries a road over a small waterway or trail with the structure entirely below the elevation of the road. Spans of less than 20 feet are not classified in NBI. Culverts have two basic forms—box and pipe. They may have single or multiple spans, also called units or cells, and often feature a floor. Culverts may be constructed in the following materials: steel, corrugated metal, concrete, timber or masonry. Timber was not a durable material for culvert construction. Masonry was superseded by concrete in the early twentieth century, but was used for later culverts in cases where stone was readily available and aesthetics were a concern.

Deck – The roadway surface of a bridge. In a deck-type bridge, the structural system lies beneath the deck (roadway).



Truss configurations

Source: New York State Department of Transportation, Bridge Inventory Manual.

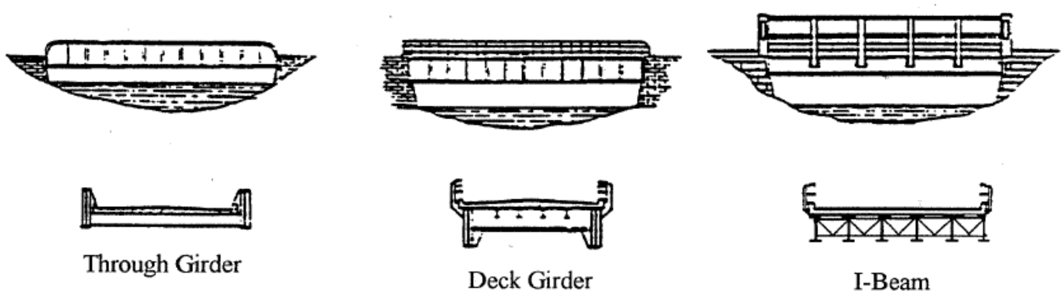
Deck arch – In a deck arch, the roadway is located above the arch ring and can feature either closed or open spandrels.

Deck truss – A truss that carries its deck on its top chord. See also thru truss and pony truss.

Diaphragm – A member placed within a member or superstructure system to facilitate construction, distribute stresses, and improve strength and rigidity.

Grade separation – A crossing of two highways, or a highway and a railroad, at different levels. The bridge that spans highways or railroad tracks (as in an overpass) is a grade separation structure.

Girder – A horizontal structural member supporting vertical loads by resisting bending. The girder bridge is composed of a series of steel or concrete beams placed parallel to traffic, resting on abutments placed on either end of the bridge. The deck is set atop the girders. The use of intermediate piers allows an almost unlimited total bridge length. Girder bridges became a prevalent bridge type in the United States in the twentieth century. The maximum length of a span is determined by the strength of the material and the depth of the girder. A plate girder is composed of built-up and connected steel plates with a deep web and top and bottom flanges.



Girder configurations

Source: New York State Department of Transportation, Bridge Inventory Manual.

Plate girder

Source: Mead & Hunt, Inc.

Lateral bracing – Members used to stabilize a structure by introducing diagonal connections.

Lift bridge – A moveable bridge type where the moveable span maintains a constant horizontal position while it rises and descends vertically. The moveable section is situated between two towers that use a system of pulleys to raise and lower the bridge. The vertical lift bridge type was designed to replace the swing bridge and be less obstructive of the waterway.

Load – Weight distribution through a structure.

Main span – Longest span in the structure (can be simple or continuous support system).

Members – One of many parts of a structure, especially one of the parts that is assembled to form a truss.

Moveable bridge – A structure with a deck that can be moved to clear a navigation channel. Depending on its height over the water, a moveable bridge may allow small craft to pass under it while it continues to carry vehicles over the waterway. When larger vessels approach, the bridge simply moves out of the way and then returns to its position after the vessel has passed. Three primary types of moveable bridges are swing, lift, and bascule.

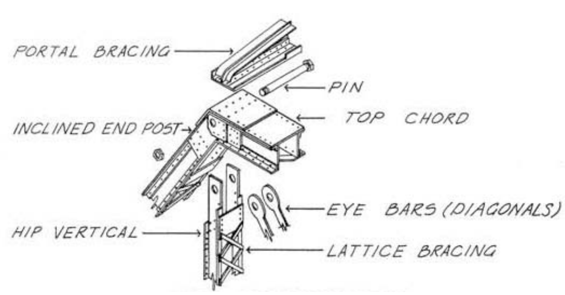
Overhead truss – In an overhead truss the roadway is located under and between the load-carrying members with traffic traveling through the truss. An overhead truss features lateral-bracing between the top chords over the deck. Also referred to as a thru truss.

Overpass – A grade separation where the highway passes over a highway or railroad.

Pier – A solid, one-piece superstructure support of stone, concrete, or timber that rests on one large footing.

Pile – A column of wood, steel, or concrete that is driven into the ground to provide support for a structure.

Pinned connections – A connection type where a cylindrical bar is used to connect various members of a truss; such as those inserted through the holes of a meeting pair of eyebars. Introduced in the 1840s, pin connections are the earliest connection type and were commonly used for trusses built before 1910s. Pin connections allowed for easier erection of bridges, much of which could be completed offsite. Pin connections remained popular until the end of the nineteenth century when they were replaced by riveted connections.



Pin Connection

Source: Historic American Engineering Record, Trusses, A Study of the Historic American Engineering Record, (National Park Service).

Pipe culvert – A structure not classified as a bridge, which provides an opening by means of a pipe under the roadway.

Pony truss – A truss that carries its traffic near its top chord but not low enough to allow cross bracing between the parallel top chords. The roadway is located between the load-carrying members. This arrangement is also called a low truss. See also deck and thru truss.

Post-tensioned concrete – The compressing of the concrete in a structural member by means of tensioning high-strength steel tendons against it after the concrete has cured.

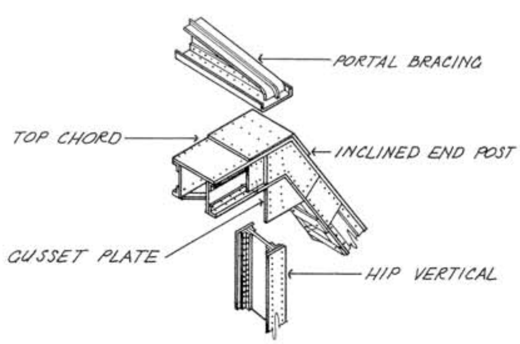
Prestressed concrete – A concrete structural member that has had an initial compressive stress applied either by pretensioning or post-tensioning. Prestressed concrete was employed beginning in the 1950s.

Pretensioned concrete – The compressing of the concrete in a structural member by pouring the concrete for the member around stretched high-strength steel strands, curing the concrete, and releasing the external tensioning force on the strands.

Reinforced concrete – The placement of metal wire or rebar in structural member forms before pouring concrete to provide additional strength.

Rigid frame bridge – A type of bridge in which the superstructure and substructure act as a single unit and were built as a continuous form. Concrete rigid frames were commonly used across the nation for highway and freeway bridge construction and generally have an arched profile.

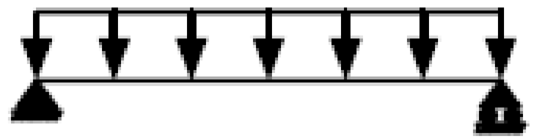
Riveted connections – A connection type using a metal shank with a large head on one end that forms its connection by passing the shank through aligned holes in the plates and hammering the second end to form a similar shape. Riveting is a common connection type for trusses and beam/girders.



Riveted Connection

Source: Historic American Engineering Record, Trusses, A Study of the Historic American Engineering Record, (National Park Service).

Simple span – Superstructure is completely supported between two supports.

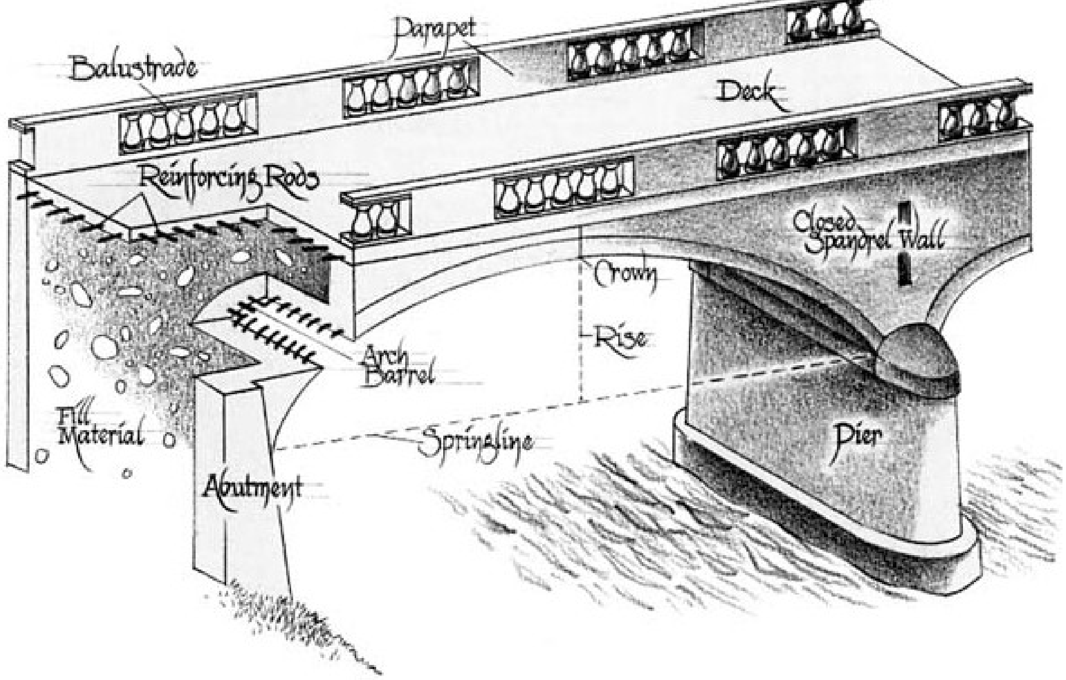


Simple Spans

Source: Michael Baker, Jr., Inc. Bridge Inspector's Reference Manual, Volume 1 (U.S. Department of Transportation, Federal Highway Administration, 2002).

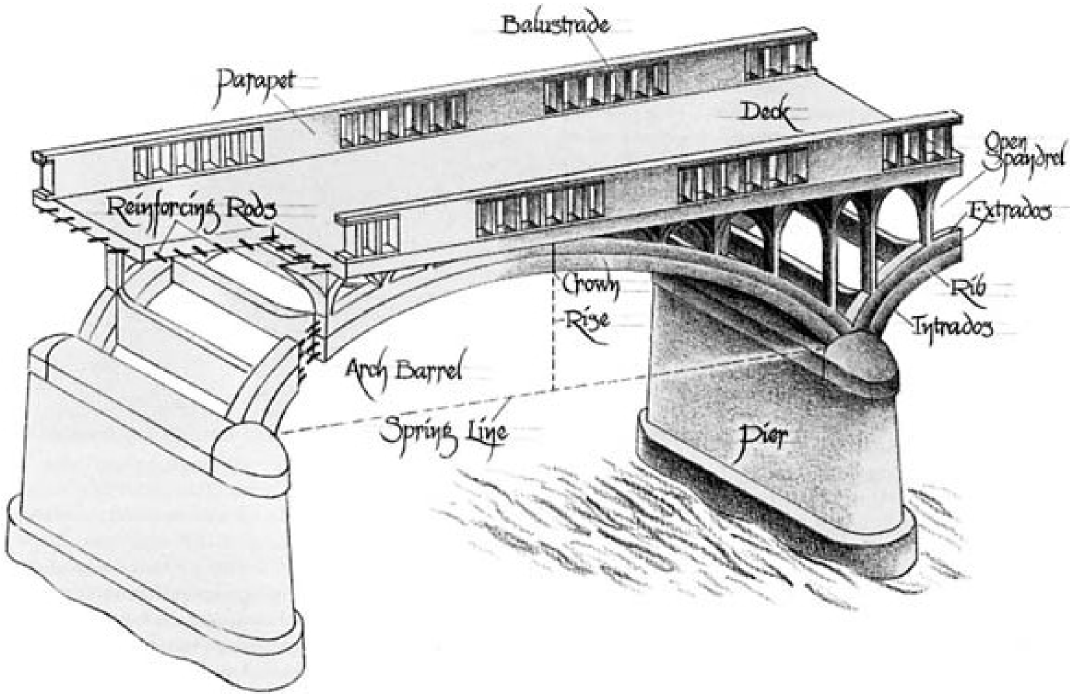
Span – The distance between two supports (either abutments or piers) of a structure; also refers to the superstructure itself.

Spandrel – The space between the arch ring and the deck on an arch bridge is the spandrel. The spandrel may be walled and filled, known as a closed spandrel, or it may be open, known as open spandrel.



Closed spandrel bridge

Source: Pennsylvania Historical and Museum Commission and Pennsylvania Department of Transportation.



Open spandrel bridge

Source: Pennsylvania Historical and Museum Commission and Pennsylvania Department of Transportation.

Spandrel braced arch – This method of concrete arch construction is characterized by the absence of a barrel ring and earth-fill to support the deck. The resulting arch is very light, uses a minimum of steel, and is efficient to construct.

Specifications – The standard specifications, supplemental specifications, special provisions, and written or printed agreements and instructions pertaining to the method and manner of performing the work or to the quantities and qualities of the materials to be furnished under contract.

Spillway – A structure used to provide for the controlled release of flows from a dam or levee into a downstream area.

Standard plan – A model set of plans prepared for a particular bridge type that can be applied to construct the same structure repeatedly with slight modifications to address particular site conditions. Frequently prepared by state departments of transportation for common bridge types spanning short or moderated distances.

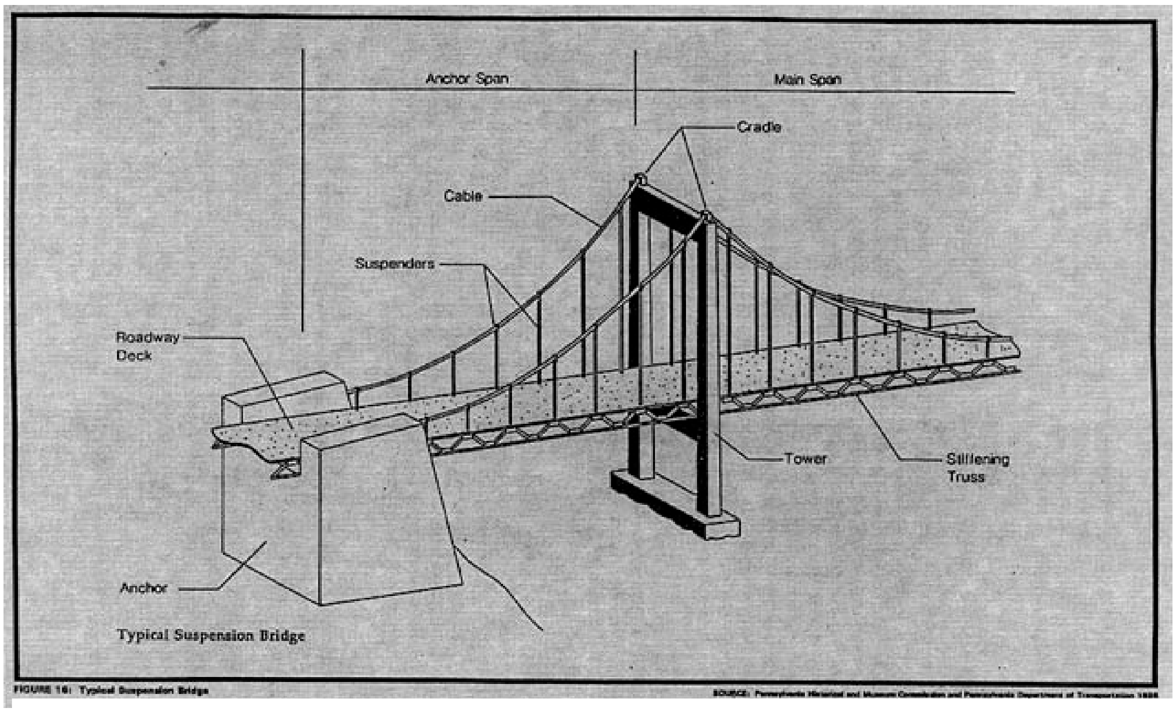
Steel I-beam – Rolled steel sections up to 36 inches in depth that support the deck and carry the load to the bearings located on the supports. The I-beam can be encased in concrete.

Stringer – A beam aligned with the length of a span that usually extends between floor beams and assists in supporting the deck.

Substructure – The abutments at either end of the bridge and, if a bridge has more than one span, intermediate supports called piers or bents that support the superstructure of a bridge.

Superstructure – The portion of a bridge structure that carries the traffic load and passes that load to the substructure.

Suspension bridge – The suspension bridge uses towers to provide vertical support for a system of iron chains or wire cables, which suspend the deck of the bridge and are anchored in their extreme ends. The suspension bridge was especially designed to accommodate long spans. The decks were often stiffened by deck trusses to prevent collapse due to external forces induced by traffic and/or wind loads. In wire cable suspension bridges, the main cable runs from the anchorage at the abutments over the tops of the towers for the entire span length. Vertical cables hung from the main cable support the deck system.



Suspension bridge

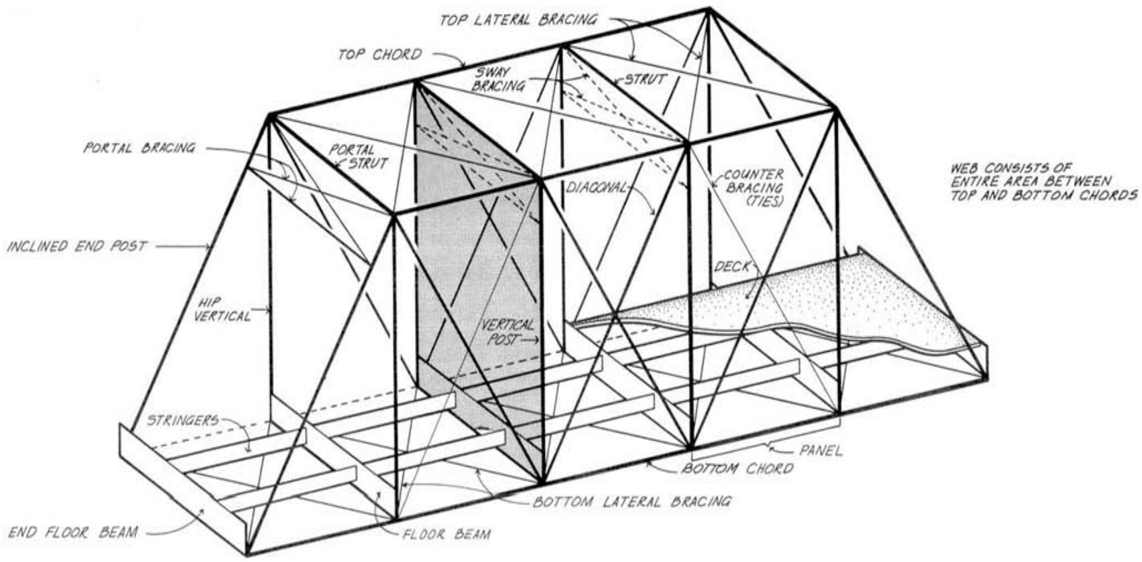
Source: Pennsylvania Historical and Museum Commission and Pennsylvania Department of Transportation.

Tension – A type of stress tending to elongate a body. It tends to lengthen a member (the opposite of compression).

Thru arch – A thru arch has the roadway passing through the arch with the crown of the arch above the deck and the foundations of the arch below the deck suspended by hangers from the arch.

Thru truss – A thru truss is most commonly defined as a truss that features lateral bracing between the top chords over the deck. The roadway is located under and between the load-carrying members with traffic traveling through the truss. Also referred to as an overhead truss. See also deck truss and pony truss.

Truss – A structural form that is made of a web-like assembly of smaller members usually arranged in a triangular pattern. A truss bridge uses diagonal and vertical members to support the deck loads. The diagonal and vertical members are joined with plates and fasteners (pins, rivets, or bolts) to create several rigid triangular shapes. This configuration allows relatively light units to be created for large spans. There are three basic arrangements of trusses—pony, through, and deck—and a wide variety of subtypes.



Truss members

Source: Historic American Engineering Record, Trusses, A Study of the Historic American Engineering Record, (National Park Service).

Underpass – A grade separation where the highway passes under an intersecting highway or railroad.

Unreinforced concrete – Before reinforcements were used, plain or massed concrete worked solely under compression and was only applicable to the arch form.

Variable depth – A slab or girder that is deeper at its ends than at the center to achieve greater span distances than can be achieved with a traditional structural form.

Viaduct – A long, multi-span bridge for carrying a road over a valley, another road, or railroad.

Welded connections – Introduced by 1930, welded connections are created by heating and melting two pieces of metal together to form a “bead” of molten steel. Used for trusses and beam/girder bridges.