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United States Department of the Interior
National Park Service

National Register of Historic Places
Multiple Property Documentation Form

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

____ New Submission XX Amended Submission

A. Name of Multiple Property Listing

Highway Bridges in Colorado

B. Associated Historic Contexts

The Historical and Technological Evolution of Colorado's Bridges 1880 - 1958
- Early Bridge Construction by the Railroads and Local Government
- Early Bridge Construction by the State
- Early Transcontinental Highways
- Depression-Era Bridge Construction
- Interstate Highways

C. Form Prepared by

name/title Clayton B. Fraser, Principal

organization **Fraser**design date 30 March 2000

street & number 420 South County Road 23E telephone 970-669-7969

city or town Loveland state Colorado zip code 80537

D. Certification

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

State Historic Preservation Officer
Signature and title of certifying official Date

Office of Archaeology and Historic Preservation, Colorado Historical Society
State or Federal agency and bureau

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

Signature of the Keeper Date of Action

Table of Contents for Written Narrative

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

page number

Primary location of additional data:

[ ] State Historic Preservation Office
[ ] Other State Agency
[ ] Federal Agency
[ ] Local Government
[ ] University
[X] Other
Name of repository: Colorado Department of Transportation

1 Introduction: Bridge Development in America

Bridges, as integral elements of a developing transportation network, have played a pivotal part in the development of America. Generally the most sophisticated components of any overland transportation system, they are also the most prominent. Not merely gauges of technological advancement in design and construction, bridges reflect the tenets, values, and ambitions of the people who erected them. "There can be little doubt that in many ways the story of bridgebuilding is the story of civilization," Franklin Roosevelt stated in 1931. "By it we can readily measure an important part of a people's progress." While descriptive of the country in general, this was especially true for Colorado, a state in which overland transportation forms a central historical theme. From the earliest wooden spans put up during the first gold boom to the later iron and steel trusses erected on wagon roads and multiple-span urban viaducts for vehicular and tramway use, bridges have facilitated, and in some instances created, settlement across the state.

A plethora of bridge forms, variously employing such materials as stone, timber, iron, steel, and concrete, were developed through centuries of empirical usage. By the time America was undergoing initial settlement on the East Coast, most of the principal bridge types and materials had been used or at least experimented with in other countries. What remained over the last two centuries has been a process of refinement revolving principally around the introduction and proliferation of structural metals and concrete as building materials.

The first wooden bridges were merely plank structures—the equivalent of a log thrown across the stream. Limited in span to the wooden beam's length and carrying capacity, they were used for only the shortest crossings. Without proper support, they became unduly strained by bending moment forces, leading to failure: the log broke. An advancement over this was the first significant bridge form in America, the pier bridge, also called the pike-and-beam bridge. Another ancient bridge type, it consisted of timber or log stringers spanning between timber pile bent piers, spaced at intervals of between 10 and 30 feet. In places where loose or shifting sediment proved unsuitable or was too deep for stone foundations, wooden piles were driven into the river to support the roadwork. A variation on the pile design, the crib bridge, used stacked logs for the piers. Timber stringer bridges were used extensively on the East Coast and further inland, as the settlement line moved westward. Consisting of multiple short spans of timber beams resting on pile bents or cribs, timber bridges were impractical across wide, deep rivers, and many were eventually replaced by timber trusses in the late 18th century. Nonetheless, timber stringer bridges continue to be the most commonly built vehicular bridge type, one that continues to be built for minor crossings.

The use of stone as a building material was also transferred to America from Europe. Long known for its compressive strength, stone (or more specifically the mortar joints between the stones) has virtually no tensile strength and must rely on compressive forces through arching. Although used extensively in Europe, stone was largely eschewed in this country in favor of timber and was used only marginally for bridge superstructures. While some stone bridges were built in situations in which strength and permanence outweighed the importance of initial cost, the use of stone was generally restricted to substructural work. Its rigidity and resistance to scouring from water made it the preferred material for piers and abutments until early in the 20th century.

Though by far the most common bridge type, the timber stringer was not really very sophisticated. More technologically innovative was a bridge type that has been termed "primarily an American achievement"—the truss. The introduction of the truss marked the beginning of more involved bridge design in America. As with other structural types, the truss form had been imported from Europe. First employed in ancient Greece and Rome as a roof support, the truss was not formally associated with bridge design in Europe until the Renaissance. But while the first timber trusses were erected there, the greater development of truss design occurred in America during the 19th century.

The extent of European influence on American designers is not known. In 1570 Italian architect Andrea Palladio described three simple truss bridges in his general treatise on architecture, *I quattro libri della architettura*, attributing their origins to well-established antecedents. Using Palladio's work (translated into English in 1742) and their own empirical designs, early American carpenters constructed wooden trusses throughout the East. "It is probable that most literate men among them were aware of European developments," historian David Plowden states. "It is also conceivable, however, that the truss, such an obvious device to anyone familiar with the rudiments of roof framing, may have evolved independently in America." [1] Prior to 1840 most of the evolution in this country involved continually more sophisticated wooden trusses and arches. In only 50 years the kingpost, the most basic form of truss, consisting of an A-frame with a central support, had developed into several more complex configurations. At the forefront of timber bridge construction in America was New England carpenter Theodore Burr, who was the first to design and build a covered bridge—the Waterford Bridge over the Hudson River in 1804. Two years later Burr patented a truss design that featured straight upper and lower chords with an arch superimposed for additional strength. Named the Burr arch-truss, it gained widespread use in America.

Between the years 1820 and 1850, truss design evolved into a more precise science. Several major truss patents were taken out during this period, a fact directly attributable to railroad development and the concurrent need for bridges of increased strength, capacity, and rigidity. The Town lattice, a lattice truss patented by architect Ithiel Town in 1820, represented the first truly American development.[2] The Long truss, patented in 1830 and 1839 by Colonel Long, was the first to incorporate panel counter-bracing systematically. Massachusetts millwright William Howe's contribution, patented in 1840, was a truss design that used timbers for upper and lower chords and diagonal compression members, but it substituted wrought iron for wood in the vertical tension members. The combination wood/iron Howe truss design constituted an improvement in spanning and carrying capacity over its all-timber predecessors. Because of its greater strength and uncomplicated erection, it became the standard timber railroad truss in America before 1850.

The structural type that became the first all-metal standard for vehicular spans was the bowstring arch-truss. New York inventor Squire Whipple patented his "Iron Bowstring Bridge" in 1841.[3] Resembling a large archery bow, Whipple's design featured a curved, wrought iron upper chord that was tied at its ends by an iron-bar lower chord acting in tension. Like most successful inventions, his bridge design spawned numerous variations, most of which deviated from his patent just enough to avoid charges of infringement. Over the next 35 years dozens of patents were issued for improvements on Whipple's design. These included such configurations as the triangular, tubular wrought iron arch patented by Cincinnati inventor Thomas Moseley in 1857, the square, tubular wrought iron arch patented by Cleveland inventor Zenas King in 1861, the parallel-plate arch patented by Wilmington, Ohio, inventors Jonathan and

Zimbi Wall in 1874, and several arch configurations patented by Canton, Ohio, bridge manufacturer David Hammond in the 1870s. In his 1874 *Book of Designs*, Hammond summarized bridge development to that point:

> The building of highway iron bridges, begun by Whipple in 1846-50, was carried on to a limited extent until 1861. . . . Wrought iron bridge work for highway purposes has made rapid progress from that date to the present time, almost supplanting cast iron, as was the case with railroad bridges, and forcing the public to concede its superiority over wood or cast iron, wherever they were brought into comparison. Starting in New York in 1845, iron highway bridges have grown in public favor until they are now found in almost every State in the Union, and even those States, such as Maine, New Hampshire and Michigan, whose facilities for building wooden bridges are unrivaled, are abandoning wooden for iron bridges.[4]

Patented in 1844 by Thomas and Caleb Pratt, the Pratt truss was similar to the Howe, except the verticals were the compression members and the diagonals tension. The first Pratt trusses, like Howe's, used a combination of wood for compression members and iron for tension. Because of its greater use of metal components, however, the Pratt truss did not gain the popularity of the Howe until the 1870s and 1880s, when the improved quality and decreased cost of iron made feasible the construction of all-metal trusses. A variation of the Pratt, patented in 1847 by Squire Whipple, featured diagonals that extended across two panels, thus providing additional lateral support for long, deep trusses. This added rigidity made the Whipple truss especially suitable for railroad use, and, due largely to the efforts of engineer George Morison, a series of long-span Whipples was built over the Missouri River in the 1880s. Another important truss type patented during this period was the Warren truss, introduced by two British engineers in 1848, and quickly adopted in America. Triangular in outline, the Warren in its classic form included only diagonal members that carried both compressive and tensile forces. Its straightforward design made it one of the standard forms for later all-metal trusses.

In the late 19th century several new truss designs were patented. The Howe, Pratt, Whipple, and Warren configurations had by that time become the mainstays of the profession for both railroad and vehicular use. The basic Pratt design was then split into a variety of sub-types—the Parker, with its polygonal upper chord; the Pennsylvania, so named for its extensive use by the Pennsylvania Railroad; the Baltimore, used by the B&O Railroad; the Camelback, described by Waddell as "uncompromisingly ugly"; the Kellogg; and the Lenticular truss—which as a group constituted the vast majority of vehicular trusses fabricated in the 19th century. Several other designs were also patented—the Pegram, Fink, Bollman, Stearns, Greiner, and Thacher among them. Esoteric, and in some cases structurally questionable, these never received wide-scale use as did the Pratts and Warrens. During this period, all-metal trusses came into far greater use, first employing cast iron, then wrought iron, then steel.

The evolution of truss components and connections in America 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. Steel eyebars, made using the Bessemer and open-hearth forging processes, appeared in the 1870s. Pinned connections, assembled in what was termed the "American style" of truss construction, 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.[5]

After the turn of the 20th century, the pattern was well-set: steel was the material to use, and no new truss designs of significance were patented. Truss design was by then a matter of refinement and expansion of existing ideas. The only major change in truss erection occurred around 1910, when rigid connections began to supersede pinned. Bridge companies used both connection methods—occasionally combining the two on a single structure—during the transitional period in the early 1910s. By 1920 erection of pin-connected bridges had virtually ceased. Concurrent with this was the emergence of the Warren truss for vehicular use. Pratt trusses were inherently better suited to American style erection, but Warren trusses proved more difficult to assemble in the field using pinned connections. When rigid-connected trusses became more feasible in the 1910s, Warrens came into their own, receiving more widespread acceptance among American bridge engineers.

Although the truss received much of the attention from the engineering profession, other types of metal bridges were undergoing simultaneous development in the 19th century. One of these was the girder. An elaboration on the simple stringer bridge, with two to six main spanning beams to which floor beams are attached perpendicularly, the girder form was associated primarily with railroad construction. The first patent for an all-iron bridge was taken out by August Canfield in 1833, and as early as 1846 an iron plate girder railroad bridge had been erected. As the cost of wrought iron decreased, girders began to proliferate during the 1870s and 1880s. With their deep profiles made up of iron or steel plates to which rolled metal flanges and web stiffeners were riveted, girders were ideally suited for railroad use because of their inherent rigidity and relative ease of construction. Their drawbacks were that they weighed more than similar-length trusses and they were typically built in-shop and hauled assembled to the sites, limiting their effective span to the length of a railroad flatcar. Nonetheless, deep-profile girders were used extensively for short- to medium-span railroad bridges from the 1880s to the 1920s. Although roadway girders were also built at that time, they tended to be significantly less economical than other bridge types and were employed principally for special-use situations, such as heavily trafficked urban bridges and viaducts.

Two other metal bridge types that received some use in the 19th century were suspension and cantilever bridges. The first suspension bridge in America was built in 1786, and by 1808 over 40 had been built.[6] Used only intermittently by the railroads due to their inherent lack of rigidity, suspension spans received increasing vehicular use through the end of the 19th century and the beginning of the 20th century. The Kentucky River Bridge at Dixville, Kentucky, built in 1876, marked the beginning of long-span modern cantilever construction. Like the suspension bridge, it is a design that received intensive use in the early 20th century.

After the turn of the 20th century, another major structural form—the reinforced concrete arch—began to receive widespread usage among American engineers. Concrete arches relied on two ancient technologies—concrete construction and the arch form—to allow a material that ordinarily acts poorly in tension to carry loads over long spans. The first use of Portland cement in America is attributed to David O. Saylor, who patented his own type of Portland cement in 1871 and built the country's first cement manufacturing plant (built in 1866) near Coplay, Pennsylvania.[7] The first documented use of concrete on an American bridge was in the foundations of the Erie Railroad's Starrucca Viaduct, completed in 1848.[8] John Goodrich was probably the first in this country to use concrete in a bridge superstructure, in 1871. He was soon followed by others, so that by the turn of the century some 150 concrete arches had been built in America.[9]

These early structures were built of unreinforced, or mass, concrete. In 1871 W.E. Ward was the first to embed steel bars in a concrete bridge to add tensile strength. After the turn of the century, engineers began building ever longer reinforced concrete arch structures, extending over 250 feet in span by 1908. Both open- and filled-spandrel concrete arch bridges were ideally suited for the memorial bridges being built by cities across the country to replace earlier iron trusses. As indicated by an article in *Engineering Record*, the truss was by then considered an eyesore on the urban landscape:

> There is one feature of city bridge building that still remains in the dark ages, and engineers ought to give it more attention. The usual criticism of our public works is that they are needlessly utilitarian and consequently ugly. Now it must be admitted that an ordinary highway truss bridge is not so charming as a well proportioned masonry arch.[10]

To conceal the stark concrete planes of their bridges, engineers often covered them with facades of real or imitation stone or formed and textured the concrete to resemble coursed masonry. Ransome had chosen to disguise the Alvord Lake Bridge, a structure at the forefront of technological innovation, with a veneer of imitation stone. "As often as not, the results were less pleasing than the structures they replaced," Plowden states. "These bogus structures satisfied the aesthetic requirements of the turn of the century and cost much less to build than an all-stone bridge, despite the over ornamentation some of them received." [11]

After 1905 concrete bridge construction experienced a marked increase, due largely to the efforts of one engineer—Daniel B. Luten of Indianapolis. Using a series of wide-ranging patents taken out between 1900 and 1906 for reinforced concrete arches, Luten absolutely controlled the concrete bridge industry in America. His lawsuits for patent infringement were routinely upheld in the courts, forcing virtually all arch builders to pay patent royalties to Luten. Luten's arches were innovative. Featuring sometimes highly elliptical profiles, they were sophisticated in their dependence on steel reinforcing and allowed relatively thin concrete sections at midspan. Termed Luten arches—or horseshoe arches for their distinctive profile—they were built extensively from 1905 through the mid-1920s.

Luten's stranglehold on the industry was finally broken in January 1918, when a Des Moines judge ruled that the broadly worded patents were invalid.[12] The Iowa location was significant, for the suit challenging Luten's patents was initiated by America's other most significant concrete bridge designer, James B. Marsh of Des Moines. The ruling opened up arch building in the country, and the concrete arch received increased use as a vehicular bridge type. Marsh himself had patented a reinforced concrete arch design in 1912, called the Marsh, or rainbow, arch. Marsh arches were essentially steel bridges sheathed in concrete, with the deck carried between two parallel arches. Costly to construct, they were built sparingly for highway use until Marsh's death in 1936.[13]

The dull color of concrete bridges and the enormity of steel trusses sparked debate within the bridge profession on aesthetics and scale. To engineers interested in technological achievement, the monumental skeletal structures of steel illustrated perfectly the relationship of form and function. Moreover, those such as Thomas Clarke saw utility and not sculptural art as of primary importance. "Where so many bridges had to be built in a short period of time, aesthetic considerations are little regarded," he stated. "Utility alone governs their design. So long as they are strong enough, few care about how they look." [14]

On the other side were those that held the arched form to be the highest kind of bridge design. Concrete arches provided the opportunity for applied ornamentation in the form of incised panels or classical balustrades that the starkly functional trusses did not. Moreover, proponents argued that the arch was structurally superior, more rigid under traffic and more resistant to flooding. Ultimately, however, the decision to build a concrete or steel bridge was often an economic one, and in most applications concrete cost more than steel.

A common thread that ran through all the major bridge types was the method of their construction. With the rise of industrialization, the settlement of the West, and the resultant proliferation of overland transportation networks, a new industry—bridge fabrication—sprang up in 19th century America. A number of companies formed after 1850 to fill the demand for roadway and railroad truss bridges. After the Civil War their numbers jumped from a total of just five in 1860, to 75 in 1870, 137 in 1890, and almost 200 by 1900. Few bridge engineers at the time fully understood stress analysis and truss design, allowing national firms such as the King Bridge Company and the Wrought Iron Bridge Company to gain power in a rapidly expanding market.[15]

These firms often published catalogues of standard structural types and bid competitively on construction contracts let by the counties and municipalities. Several firms in the Midwest and the Ohio River Valley specialized in bridge fabrication and erection. Constantly on the road, their salesmen contacted counties where rapid population growth produced a demand for large numbers of bridges. When an order for a bridge was received, its components were assembled at the fabrication plant. Bridge fabricators sometimes erected the parts at the site as well. Other firms, particularly local ones, received county bridge contracts but were responsible for erection only, purchasing steel superstructures from fabricators such as the Minneapolis Steel & Machinery Company.

In 1900 the complexion of the industry changed radically. That year financier J.P. Morgan created the enormous American Bridge Company by consolidating two dozen smaller firms, including the Wrought Iron Bridge Company (Canton, OH), the Edge Moor Bridge Works (Wilmington, DE), the Gillette-Herzog Manufacturing Company (Minneapolis, MN), the Milwaukee Bridge & Iron Works (Milwaukee, WI), the Groton Bridge & Manufacturing Company (New York, NY), and the Youngstown Bridge Company (Youngstown, OH). This effectively molded most of the competing firms into one gargantuan company, which then fabricated and erected thousands of railroad and vehicular bridges across the country. Against this giant of the industry, several smaller firms still managed to compete, mostly from bases in the West and Midwest. These included companies such as the Missouri Valley Bridge & Iron Works (Leavenworth, KS), the Kansas City Bridge Company (Kansas City, MO), and the Midland Bridge Company (Kansas City, MO), as well as the Colorado-based Pueblo Bridge Company and the Charles G. Sheely Construction Company of Denver.[16]

After 1900 the bridge companies had two more decades of intense activity before the industry again changed. Following the passage of the Federal Aid Road Act in 1916, bridge design generally fell to the state highway departments, and contracting became more localized. National bridge firms offering design/build services to the counties could no longer remain competitive in this changing market. The industry change also marked the shift from the design of wagon bridges to those intended specifically for automobile use.

2 Early Bridge Construction by Railroads and Local Government

As the East was experiencing the nation's greatest surge in bridge innovation in the 1840s, Colorado received only a trickle of emigrants passing through on the way to other places. The eastern half of Colorado had first entered the Union as part of the Louisiana Purchase. At the time of the land transfer, neither Napoleon Bonaparte, who sold it, nor Thomas Jefferson, who bought it, knew exactly where the western border of the purchase lay. The issue was rendered moot when western Colorado came into the Union after the conclusion of the war with Mexico in 1848. Native Americans, Spanish explorers, fur trappers, and scouts traveled Colorado territory on foot and on horseback, blazing trails through the mountains and plains, long before the development of a formal road system. Many of the routes forged by these early explorers were used as later wagon roads and eventually highways. This is hardly surprising given that the early routes sought the easiest way to pass through the country and frequently followed rivers and natural byways, seeking the path of least resistance.

Prior to the 1859 Colorado gold rush, Anglo explorers produced most of the written descriptions of Colorado. In 1806 Zebulon Pike led an expedition to the southern part of the Louisiana Purchase, exploring into Colorado along the Arkansas River and part of the way up his namesake peak. In 1820 Lt. Stephen Long of the U.S. Topographical Corps led an expedition that followed the South Platte to the site of present-day Denver and then, failing to find a pass through the mountains, south toward New Mexico. Long's expedition is most famous for its leader's damning characterization of the eastern plains of Colorado and the entire region of the Central Plains as the "Great American Desert"—a place "almost wholly unfit for cultivation." For years the problems of a high, treeless and arid region proved too novel a situation for the first droves of pioneers bound for the West Coast. Possessing an Eastern bias against a country not covered with trees, most believed the soil to be worthless because it did not support lush foliage. Washington Irving, in his 1836 account of the fur trade, *Astoria*, characterized the High Plains as "undulating and treeless plains, and sandy wastes, wearisome to the eye from their extent and monotony." The region was generally considered to be an obstacle or barrier to be crossed quickly. Additionally, its daunting north-south chain of mountains effectively diverted emigrant traffic to either side of the Colorado region.

The only major route to cross Colorado from the 1820s through the 1840s was the Santa Fe Trail. Linking St. Louis and Santa Fe, the northern branch extended along the Arkansas River to Bent's Fort, and then south over Raton Pass to Santa Fe. Fur trappers and traders forged several other early overland routes through the state. The Trappers (or Taos) Trail ran between Laramie, Wyoming, and Taos, New Mexico, following the Front Range of the Rocky Mountains, over Sangre de Cristo Pass, through the San Luis Valley, and then along the Rio Grande to Taos. The Smoky Hill Trail followed the "Golden Belt" route to Oakley, Kansas, then traced the Kansas River west to the Smoky Hill River, past present-day Cheyenne Wells, Limon, and Denver. This route was later used by D.A. Butterfield for his stage line to Denver and Salt Lake City.[17]

Another trail entered the region from the northeast and followed the South Platte River to a point near Greeley, where it branched westward and northward to La Porte, Virginia Dale, and up into Wyoming. Called the Overland Trail after the stage line that improved and used it in the early 1860s, it also branched off toward Denver at three locations—one across the plains near Fort Morgan, one at Latham, and one at La Porte near Fort Collins. Cherokee gold seekers en route to California in 1849 created the Cherokee Trail, following the Arkansas River to El Pueblo, later Pueblo, and then taking the Trappers Trail north to the Overland Trail.[18]

This latter group is credited with the discovery of gold along the Platte River in Colorado. The Cherokees had mined gold on their ancestral lands in northern Georgia before the government drove them out. Some prospected as they made their way west to California, and William Green Russell heard about Colorado gold from Cherokee prospectors while he was in Sacramento. Disappointed by the yields in California, Russell in 1858 organized a small party to venture to Colorado. There, just north of the confluence of Cherry Creek and the South Platte River, Russell and his group discovered placer gold. Additional gold discoveries followed on the heels of the first, as others found gold up Boulder Canyon near present-day Gold Hill, up Clear Creek Canyon near Idaho Springs, and near Black Hawk.[19]

News of the gold strikes spread rapidly, spawning the legendary gold rush of 1859. One hundred thousand gold seekers are said to have set out for Colorado that spring from Missouri River towns such as Atchison, Kansas City, and Leavenworth. Of those that started out, about half either quit or died along the way. Of the 50,000 who made the trip, probably half gave up and headed home soon after arriving at Cherry Creek. Traveling in both directions, many followed the older trails: the Overland Trail along the Platte and then south on the old Cherokee or Trappers Trails, or the Santa Fe Trail up the Arkansas and then north to the gold fields. Some took new overland routes that had been discovered during the explorations of the last several decades.[20] Travelers from Kansas City often followed the Kansas and Smoky Hill Rivers across Kansas and then struck out across the eastern Colorado plains to Denver. This was the shortest route, but also the most dangerous, most difficult, and the one with the scarcest water supply. A few adventurers forged a new trail west from Leavenworth along the Platte River Route, bearing west along the Republican River and then across the plains to Denver. This was the least popular route. Once in Colorado, prospectors clustered in the new towns at the mouths of placer-rich canyons and then blazed trails up the mountain canyons to the mines by foot, ox cart, and horseback. Many of these new pathways would later become public roads.[21]

Colorado's first cities grew up along the foothills where avenues into the diggings crossed the main north-south trail, the Cherokee Trail, or the Trappers Trail. Denver, Golden, Boulder, Colorado City, and Pueblo all provided gathering places for gold rushers. Golden was well situated at the mouth of Clear Creek, the gateway to both Idaho Springs and the Black Hawk/Golden strikes. Boulder provided access up Boulder Canyon to Gold Run (near present-day Gold Hill) as well as a second avenue to Black Hawk. Pueblo, the only one of the "new" towns that was relatively less new (it had been founded in the early 1840s), stood where the Santa Fe trail intersected the Cherokee and Trappers Trails. Denver was perhaps the best situated, located where the Cherokee Trail crossed the South Platte. It was the easternmost supply center and therefore often the first city encountered by travelers from the east.[22]

Initially named St. Charles, Denver had been founded on the east side of Cherry Creek by a group of prospectors from Lawrence, Kansas. As other prospectors began pouring into the Cherry Creek area in autumn 1858, a second town was platted by the Auraria Town Company immediately across Cherry Creek from St. Charles. When General William Larimer and his group arrived in mid-November, they took over the St. Charles townsite and renamed it Denver City after the governor of Kansas Territory, Gen. James W. Denver.

The location of Auraria, Denver, and a third townsite named Highlands around the confluence of Cherry Creek and the South Platte River dictated that bridges be built to link the three communities.

While officials from Auraria and Denver haggled over bridge building, a charter was granted by the Kansas Territorial Legislature in February 1859 to some of the founders of Auraria to operate a ferry across the Platte at the mouth of Cherry Creek.[23] The charter soon passed to Kentuckian Thomas Warren, who operated a rope ferry, consisting of a heavy rope tied to trees on either bank to which a flatboat was attached through a series of pulleys. Charging $1 per wagon and team, Warren turned a handsome profit. The first bridge of record in Denver (and probably Colorado) appeared in the "Local News" section of the June 8, 1859, *Rocky Mountain News*: "Messrs. Smith, Chubbuck & Co. have recently completed a substantial bridge over the Platte at this place." Smith et al. owned the "Pioneer Farm" across the river from which they planned to raise and sell produce. At the same time a bridge was underway over Clear Creek near Golden.[24]

Denver's first timber span was followed by two others early in 1860. In January E. Karczewsky, an Iowan who was later a partner in Denver's first bakery, constructed a bridge across the Platte at Ferry Street (now 11th Street). And in April another bridge was built across the Platte from Auraria, at the west end of Larimer Street. According to Denver historian Jerome Smiley, it was "not a very substantial affair, but the Auraria Directors took it off the builders' hands, giving them '60 lots at $10 each,' for it."[25] The first contracted bridge was to have been built by Thomas Bayaud late in 1859. In September Bayaud approached the Denver town managers with an offer to erect a bridge over the Platte, and the following month he was contracted to build it for $2500. But problems arose, and when Bayaud had not yet begun the work the next spring because of financial disagreements, Sam Curtis, an old friend, convinced him to continue. "As I had again become connected with the Denver Town Company," Curtis recalled, "I was on a committee to settle with T.J. Bayaud for building a bridge over the South Platte river at the foot of Fifteenth street. After many evenings, and drinking many of his whiskey punches, we finally reached a settlement." Another bridge was apparently completed in 1860 over Cherry Creek at Larimer Street.[26]

As Auraria merged with Denver and the city developed, the web of bridges over the river and creek continued to grow, until a flood in May 1864 washed them all away. According to Smiley:

> From the beginning of things here in 1858 until May, 1864, historic Cherry creek had been an inoffensive little stream in certain seasons of the years, and an invisible one in the other seasons with its broad sandy bed hot and dry. After midnight the creek suddenly became an angry, roaring torrent that exercised its long-reserved powers of devastation without warning. Wreckage piling against the creek bridges, low, wooden affairs, had early in the proceedings loosened them from their bearings and away they had gone. The South Platte had risen to an unprecedented stage, flooding far beyond its nominal limits, and had quickly demolished the bridge at the foot of Eleventh street and another at the foot of Fifteenth.[27]

Bayaud's 15th Street Bridge and Karczewsky's 11th Street Bridge were soon reconstructed with the others. They washed away again in July 1875. Reconstructed, they were washed away once more in May 1878:

> The creek again asserted its destructive power by carrying out most of the bridges in its way and flooding the districts in the lower part of the city. Within two hours each bridge in the city was made a flooding dam and then successively carried away. They were cheap wooden affairs with their supports in the creek bed, and were later replaced by properly constructed iron ones.[28]

By that time Colorado had been admitted into the union and Denver had grown into a respectably sized city. The flimsily constructed wooden pile bridges began to give way to far more substantial iron (and later steel) trusses for the more heavily trafficked crossings of the Platte within a couple of years after the 1878 flood. In 1887 the first of the great iron/steel viaducts was constructed over 23rd Street to connect Denver with property that was being promoted by the Denargo Land Company as suitable for industrial use.[29]

The following year the City of Denver contracted with the Missouri Valley Bridge and Iron Company to erect a two-span iron truss over the Platte River at 19th Street. Costing $25,000, the 19th Street Bridge [**5DV535**] replaced a ten-year-old timber structure, built immediately after the 1878 flood. It is today the oldest originally situated vehicular bridge in Colorado. That same year the Denver Tramway Company was given a charter to operate cable cars within the city. Construction was soon begun on two steel girder viaducts to elevate the company's cars over 16th and Larimer streets. Completed in 1889, they were described by Smiley in 1901:

> The Larimer Street Viaduct, beginning at 7th Street and by a sharp grade rising to the level of the tops of three-story buildings, crossing streets, railroad tracks and the Platte river . . . , is 3,600 feet long; constructed . . . at a cost of about $125,000. It is for [cable] car purposes only, but could be adapted to vehicle traffic and for foot travel. The Sixteenth street viaduct, from Wazee street, near Union Station, crossed railway tracks and the Platte river to Platte street in 'North Denver.' It is 3,600 feet long . . . and cost about $180,000.[30]

In 1895 the cities of Denver and Highlands formed the 14th Street Improvement District to raise money for the construction of the 14th Street Viaduct. Construction was began later that year by the Youngstown Bridge Company and finished in 1898 for an aggregate cost of $367,068—by far the most costly bridge in the state to date. With 63 spans totaling 1467 feet, it was the last of the original 19th century viaducts designed to carry wagons, trams and pedestrians.

As Denver expanded, settlement throughout the rest of Colorado followed suit. Beginning in 1859, the gold-hunting mania extended up the mountain valleys to form the mining towns of Aspen, Central City, Black Hawk, Breckenridge, Georgetown, Idaho Springs and Silver Plume, among many others. These were virtually all accessed by toll roads that had been snaked up into the mountains by private road companies. Placer mining soon exhausted the easily gathered gold from the streams and sandbars, however, and was being replaced by deep-rock mining, which required considerably greater manpower and equipment. It soon became apparent that more substantial transportation networks than the narrow, winding mountain trails were needed, and that these networks should be railroads.

Railroading and mining were about as well suited for each other as two large-scale industries could be. Mining involved the shipment of large, cumbersome loads—heavy equipment in, heavy ores out—over precipitous terrain. Although horses and wagons or mules could carry the loads, and many of Colorado's mines relied on horse-drawn transportation to some extent throughout their producing years, the wagons' capacity was dwarfed by that of the trains. Furthermore, horse-drawn transportation was slower and more susceptible to weather-caused interruptions than railroads. Because of their continuous need for the type of massive hauling power that trains were best suited to deliver, mines and smelters proved ideal customers for railroads. Districts served by railroads tended to prosper more and last longer than those dependent solely on horse-drawn transportation, and railroads that served prosperous mining districts could generally remain solvent. For this reason, mining districts and railroads sought out each other with almost equal fervor. Historian Rodman Paul, in his study of the mining frontier, stated that no factor signaled the end of the frontier phase of mining in the West more than the arrival of rail transportation.[31]

When Congress passed the Pacific Railway Act in July 1862 to charter the first transcontinental railroad, boosters in the Pikes Peak region were elated. This later turned to disappointment when the Union Pacific was routed, not through Colorado, but across southern Wyoming in 1867 and 1868. Businessmen and miners in the territory immediately looked to two railroads for possible help—W.A.H. Loveland's Colorado Central, which would ostensibly drop down to Golden from the Union Pacific line in Wyoming, and the Kansas Pacific, which would cross the eastern plains along the Smoky Hill route to Denver.

In late 1867, when the Kansas Pacific sputtered short of the territorial border out of money, and the Colorado Central was having construction problems of its own, a third possibility—the Denver Pacific—was planned. Extending from the Union Pacific railhead at Cheyenne, it reached Denver in June 1870—the first completed railroad into the state. Two months later the Kansas Pacific, flush with cash from generous federal land grants, also reached Denver from the east. The Colorado Central was the first railroad to build to the gold districts. In 1872 the CC laid narrow-gauge tracks from Golden to Black Hawk, up the "tortuous and steep-walled canyon" carved by Clear Creek. The railroad's effect on Black Hawk was nearly as dramatic as that of the new smelter, built in 1868. After rails reached Black Hawk, the expense of machinery fell, and the price of food, clothing and fuel dropped, allowing wages also to drop. All of this resulted from the lower freight rates that the Colorado Central could offer. While freight rates fell, the precious metals exported from Black Hawk maintained their value, further increasing the railroad's value. The Colorado Central also planned to reach Central City, Idaho Springs and Georgetown and laid additional track up Clear Creek Canyon toward the latter two mining areas before the Panic of 1873 halted construction. It would take the railroad until 1878 to reach Central City, barely three miles from Black Hawk.[32]

The Colorado Central was soon eclipsed by another rail company seeking to tap into the wealth produced by Colorado's mining districts. Founded in October 1870 by General William Jackson Palmer, formerly of the Kansas Pacific Railroad, the Denver & Rio Grande Railroad would become one of the most important players in the development of the region's mines, literally changing the shape of railroading in Colorado. Using a narrow-gauge line, the D&RG laid its first tracks in 1871 south from Denver to Colorado Springs, a town it had created and colonized to support the railroad. The following year the D&RG's narrow tracks reached Pueblo. Passengers could ride from Denver to Pueblo, a distance of 118 miles, in eight hours. Although the railroad did not have to create Pueblo as it had Colorado Springs, it did expand the town. Built by a D&RG subsidiary, the Central Colorado Improvement Company, a new settlement called South Pueblo "rose like magic" south of the Arkansas River. In South Pueblo Palmer built the Colorado Fuel & Iron plant to produce materials for his expanding railroad empire. From Pueblo, Palmer executed a three-pronged attack, with lines extending south to Santa Fe via Raton Pass, southwest to the San Luis Valley via La Veta Pass, and west to Salida via the Arkansas River gorge.[33] The D&RG spent the next 40 years building tracks throughout Colorado, linking towns such as Leadville, Creede, Durango, Montrose, Glenwood Springs, Rifle and Craig with its narrow-gauge rails. By 1917 the company had laid some 2500 miles of track in Colorado and Utah.[34]

The 1880s marked Colorado's most prolific decade of railroad construction, as the Rio Grande and other companies such as the Colorado Midland, the Colorado Southern and the Denver, South Park & Pacific snaked tracks through the mountains. In three years—from 1880 to 1883—more track was added than had been built during the preceding thirteen years. Construction then slowed during the middle of the decade, only to rebound with its biggest single year ever in 1887. By the end of the decade, Colorado had three times the railroad mileage it started with in 1880. The state's population growth and economic development were tied directly with this expanding railroad network. In 1860 the population for the Colorado portion of Kansas Territory was listed as 34,277 and consisted almost entirely of prospectors and camp followers. That number increased by only about 5600 over the next decade. With the coming of the railroads, the 1870s marked a time of intense growth, as the state's population more than quadrupled to 195,000. By 1890 the population had burgeoned to 413,000, and over the previous decade assessed property valuation had tripled and there were four times as many farms and six times as much capital invested in manufacturing.[35]

By 1890 track traversed Colorado, crossed the continental divide numerous times, tunneled through the divide, and reached beyond state borders not only to the east and north, but also west into Utah and south toward the Gulf of Mexico. Leadville, Gunnison, Aspen, Durango, Silverton, Creede—all of these formerly remote locations now had regular rail connections, and some locations boasted more than one line. Although still not on a true transcontinental line, Denver was firmly linked to Nebraska and points east, and its traffic no longer depended on the Union Pacific alone as its eastern carrier. A route south through Texas to the Gulf of Mexico provided sea-lane access to the eastern markets as well. And a winding, narrow-gauge route climbed west through the mountains to link Denver with Utah and points west.

The mines and their explosion of silver, gold, lead and other minerals provided the magnet that drew the railroads into the mountains. For twenty years, from about 1880 to the end of the century, Colorado's mineral production never fell below $21 million a year. Colorado railroads were criticized in the press. They were frequently financially unstable and would sometimes go bankrupt. They would war with each other, and their trains would often derail. But they were also highly sought after. Every mine, every agricultural settlement, every smelter, everyone in Colorado, it seems, wanted rail connections. As people in the mining towns conducted a lively commerce down the mountains, the supply towns of the front range flourished as well. And tourists found their way to Colorado in increasing numbers, drawn partly by the marketing efforts of the railroads.

All of this heavy mountain construction meant that the railroads were compelled to build bridges by the hundreds. With the mountains full of available softwood trees and ample stands of cottonwood and pine on the eastern plains and western slope, timber was an ideal material for heavy construction. Compared with alternative materials—primarily stone, steel and concrete—timber was by far the most economical resource with which to build bridges in the 19th century. The high cost of manufacturing and shipping iron from the eastern rolling mills, added to the physical inaccessibility of many areas in Colorado, made iron and steel construction generally too expensive for bridge use. Similarly, concrete, which relied on Portland cement produced in eastern mills, was prohibitively expensive for all but the most limited uses.

Made up of many relatively small parts nailed or bolted together, timber bridges could be built relatively quickly, which was a decided advantage for railroads rushing to reach booming mining districts. Moreover, timber construction was readily understood by virtually everyone in the building trades. Carpenters using pattern books or empirical knowledge could build all manners of timber bridges with limited tools and only a rudimentary degree of craftsmanship. Steel work, on the other hand, required more specialized equipment and training. And concrete bridge technology did not develop to the point where it could be used economically for bridge superstructures until after the turn of the 20th century.

It was not surprising, then, that the railroads relied heavily on timber construction in the 19th century. The most commonly built railroad bridge in Colorado was the timber trestle, also called the timber pile or timber stringer bridge. The timber trestle was made up of timber beam or stringer spans supported by heavy timber plates atop timber pile bent piers and abutments. The individual spans were never very long, rarely exceeding 25 feet in length. Each consisted of a series of timber beams placed in rows parallel with the tracks, over which a ballast bed was laid or a second row of perpendicular ties was bolted. One of the advantages of timber pile bridges was their flexibility. They could be built in single-span configurations over minor streams, or large numbers of spans could be linked together to cross major rivers with wide flood plains.

Timber stringer bridges in single- and multiple-span configurations were built in abundance in both the flatlands and the mountains, but the mountain bridges have proved more notable. Without question the most spectacular use of timber in railroad bridge construction in Colorado occurred on the Rio Grande Southern, built in the early 1890s between Durango and Ridgway. The Southern as originally built had some 142 bridges scattered along 172 miles of mainline track, for an aggregate structure length of over two miles. Comprised primarily of cedar timbers, these bridges extended as long as 575 feet, many spanning perilously deep gorges. Spindly mountain trestles such as those erected at Ophir made the mountainside look like a roller coaster. With their successive steps of trestlework built high over the precipitous canyons, they provided as much passenger interest, if not out-and-out terror, as the spectacular scenery in which they were built.[36]

Though by far the most common bridge type, the timber stringer was not particularly sophisticated and was limited to crossings that permitted the use of relatively short spans. For crossings that required longer spans, the railroads typically employed timber/iron combination trusses. Howes and Pratts were by far the most common of the railroad truss designs, accounting for over 95 percent of railroad trusses built in Colorado. Narrow-gauge railroads such as the Rio Grande Southern and the Denver & Rio Grande used them extensively in the mountains wherever the stream conditions precluded the use of trestles.

As flexible and economical as timber was for railroad bridge construction, it carried liabilities of its own. The most serious of these was its vulnerability to the elements. Wooden bridges were susceptible to fire, and, although railroads typically stationed barrels of water or sand nearby for fire-fighting, trestles and trusses were frequently destroyed by sparks from passing trains. Wooden bridges also aged quickly, especially in the mountain environment, requiring periodic rehabilitation to keep them serviceable. Even with continuous maintenance, wooden trestles were generally expected to last only 20 to 30 years. The pile bents were also more vulnerable to scour at stream level than concrete or stone substructures, causing frequent washouts. Finally, timber bridges lacked the structural rigidity that characterized steel or concrete structures. With hundreds or thousands of individual boards connected by bolts—and each bolt hole subject to crushing of the wood fibers—timber trestles tended to "loosen up" over time under the pounding of the massive locomotives.

The temporary nature of these bridges reflected an overarching philosophy then held by the majority of the state's railroads. The difficulty of raising financing plagued virtually every railroad that had laid track to date in Colorado, with the possible exception of the Union Pacific. As a result, the funds raised were stretched as far as possible. Wherever railroads could shave costs in material or construction, they did. As a result, railroads in Colorado were not built to last. A railroad entrepreneur told potential Paris investors that initial building costs per mile were significantly lower in Colorado than those in Europe, partly because construction was expected to last only ten years. Operating profits were expected to pay for subsequent upgrades and replacement costs.[37]

The strategy of building cheaply and deferring permanent construction has been called "placer railroading." It may have been the only way to finance railroad construction in the West, but it came at a price. While placer railroads themselves risked bankruptcy and takeover, their passengers and freight faced more immediate physical danger. Placer railroads were often overcapitalized and frequently failed to pay dividends. Railroad directors knew this and often secured their profits during construction. This left railroads strapped for both construction and operating funds and vulnerable to takeover. On the engineering side, steep grades, sharp turns and generally cut-rate bridge construction resulted in a distressing number of derailments and train wrecks.[38]

There were notable exceptions to this, of course. When the Colorado Central Railroad needed to climb a steep, narrow canyon at Devil's Gate just west of Georgetown, it employed Union Pacific engineer Robert Blickenderfer to design an ingenious solution: a 300-foot-long trestle that would allow the track to ascend in a more feasible grade by doubling back over itself in an engineered loop. Combined with miles of curves surveyed over the canyon's landforms, the Georgetown Loop [5CC9] would allow the train to traverse the two miles to the next mining camp of Silver Plume on a steep, but feasible, 4 percent grade. Construction supervisor Robert Brewster Stanton ordered the wrought iron trestle towers fabricated by contractors Clark Reeves and Company of Phoenixville, Pennsylvania, a company that would later incorporate as the Phoenix Bridge Company, one of the country's premier bridge fabricators. The contractors initially installed the towers backwards over the stone pedestals so that the trestle ran downhill instead of uphill. After Stanton rejected the initial installation, they hastily reconstructed the trestle in the right configuration. Stanton also found riveting problems, which Clark Reeves fixed, attributing it to the difficulty of convincing skilled riveters to scale the dizzying structure over the rocky canyon and rushing waters of Clear Creek. Finally in 1884 trains steamed from Georgetown, over the "High Bridge" and into Silver Plume.

The Colorado Midland Railroad encountered similar difficulties with its own steel viaduct over Maroon Creek just west of Aspen. To design the immense 650-foot-long structure, the CM hired respected civil engineer George S. Morison. Morison used a structural configuration that he had pioneered in 1875 on the Portage Viaduct in New York and had later used for the Boone Viaduct in Iowa and the Marent Viaduct in Montana. He delineated a structure with 20 plate girder spans supported high above the valley on a series of nine tapered steel piers. Each pier was made up of two bents—Morison's innovation, which had since been adopted as the industry standard—each of the four legs made up of two back-to-back steel channels with cover plate and double lacing. The bent legs were braced laterally by tiers of compression beams and tension eyebars and were supported by massive stone masonry piers. The railway deck was carried on two deep deck girders, each made up of iron plate webs, riveted angle flanges and web stiffeners. Morison's viaduct was to have arrived at Aspen in pieces for assembly by railroad steelworkers late in 1887. The mill was late in delivering the material, however, and when the Midland tracks reached the valley in December 1887, the railroad was stopped cold. After building nearly 250 miles of standard-gauge track into the mountains in a single year, the Midland was forced to wait frustratingly close to its goal as the trestle's superstructural steel was delayed from the fabricator in the East. The steel for the Maroon Creek Viaduct reached Colorado later in December, and the steelworkers labored through the bitter winter to erect the immense trestle. Working at breakneck pace, they completed the Maroon Creek Viaduct [5PT136] in early February 1888.[39]

Both structures could have been built using timber trestles; timber bridges had been built by other railroads under similar circumstances. Timber construction would have avoided the fabrication and erection problems that the engineers encountered at both sites. Instead, their all-metal superstructures and pier legs distinguished them among

Colorado's early bridges. The Georgetown Loop in particular became famous as a Gilded Age tourist destination, after William Henry Jackson photographed the breathtakingly tall trestle and the railroad advertised it. From 1884 through the end of the century, tourists came to "do the loop." [40]

While Colorado's railroads did little to advance the science of civil engineering, other railroads in America could claim credit for nearly all innovation in bridge design and construction in the 19th century. "The introduction of railroads in the United States came in 1829," J.A.L. Waddell stated, "and with it began the real development of bridge engineering." Railroads pioneered the use of steel for bridge construction, devising new ways to take advantage of the material's potential. Railroads also were first to use concrete for bridge piers. Additionally, railroad companies at the turn of the century experimented with deck surfaces, such as creosoted wood, and were soon copied by highway bridge engineers. An engineer in 1929 proclaimed: "There is no doubt that twenty years ago the science and art of bridge design had found their highest expression in railway bridges. Specifications were more adequate, inspection more rigid . . . than in the highway field." [41]

Colorado's peak railroad period—from 1893 to 1913— began with a severe financial depression and ended with the state at the height of its operated railroad mileage. In 1890 some 1570 miles of railroad extended across Colorado; by 1910 there would be 5532, climbing just a bit higher by 1913 before beginning the slow decline to the present. At the turn of the century, silver was no longer the economic driving force behind railroad construction; gold, coal, lumber, stone, agricultural products and tourists were instead responsible for the stimulation of new construction. Much of the state's rail-building at that time entailed filling gaps in the system. Fewer new lines incorporated and built track, although one—the Moffat Road—built substantial mileage over difficult terrain with transcontinental ambitions. Three or four big railroad powers then dominated the state. The Union Pacific, Denver & Rio Grande, and the Chicago, Burlington & Quincy, through its subsidiary the Colorado & Southern, became the major railroad powers in Colorado. Each of these big players was transformed during this period, and none looked the same at the end of the period as it had in the early 1890s.

Neither, of course, did Colorado itself. The state's population had doubled between 1890 and 1910. In 1890 Colorado's population numbered 413,249; it was 539,700 by 1900. After a surge during the first decade of the 20th century, the 1910 census counted almost 800,000 residents. During the same period irrigated acreage nearly tripled, the number of people working in agriculture doubled and the number of people working in manufacturing grew 2½ times. Throughout all this, railroads remained a pivotal part of the state's growth.[42]

By 1913 a fully developed system of railroads traversed the mountains and plains of Colorado. Standard gauge dominated track width, although narrow gauge still held sway in the mountains, and odd widths could be found on some specialty lines. Colorado's big three—Union Pacific, Burlington and Rio Grande—controlled much of the state's rail traffic. The three essentially stayed out of each other's way; Union Pacific country lay north of Denver, the Burlington dominated north-south traffic along the front range and its own connections east, and the D&RG still held the mountains. These patterns would hold to the end of the 20th century.

Colorado railroads, at the peak of their operating influence, carried the seeds for their own decline. The expense and difficulty of building and operating railroads coupled with the undeniable advantage that railroad access gave to any community it reached had combined to make the rail companies powerful. Any community served by only one railroad could almost count on paying higher freight rates than areas where two or more railroads competed for passengers and freight, as railroads used their advantage to the fullest. This practice angered and frustrated people who were dependent on railroads to ship their products to market, and who despaired of getting the best return because higher freight rates made their products less competitive. In addition, railroads were notorious for giving favorable freight rates to high-volume shippers, often in the form of rebates, further frustrating small-scale shippers who found it hard to compete with larger enterprises. Railroad laborers also began to band together to negotiate for safer working conditions, better pay and shorter days. All of these changes at the turn of the century meant that railroads, although critical to Colorado's communications and commerce, had garnered little good will in the hearts of the people dependent upon them. This climate of resentment set the stage for shippers to embrace a different form of transportation—the automobile—as soon as the technology presented itself.

The railroads had spawned an unprecedented period of economic growth in Colorado during the 19th century. As towns sprang up along rivers, rail lines and almost everywhere else across the landscape, impromptu systems of overland roads began to develop to link them together. Vehicular road and bridge construction during the territorial and early state period was ostensibly the responsibility of the individual counties. Rarely following a premeditated plan, county commissioners would authorize the surveying and clearing of roads and construction of bridges as needed, usually in response to urgent local petitions. In the sparsely populated areas outside of the major cities, however, with minimal government revenues, relatively few vehicular bridges were built before the 1890s. Little is known about bridge construction practices of the territorial era. No bridges survive from this period and even documentary evidence is rare. It appears fairly certain, however, that early design and construction were undertaken empirically and that the bridges varied widely in their structural soundness.

The inability of the local governments to keep up with the burgeoning demand for roads and bridges, especially in areas with difficult mountain terrain, led to the proliferation of privately operated toll roads and ferries. The state's first toll road was reportedly built in 1863 between Bijou Creek near Fort Morgan and Denver via Watkins and Bennett. Three years later Uncle Dick Wootten opened a toll road in the southern part of the state. After first obtaining charters from both Colorado and New Mexico, he built a route over Raton Pass that roughly followed the Old Mountain Branch of the Santa Fe Trail.[43] Others of varying length and quality were operated intermittently throughout the state, but no toll collector functioned on a scale to rival that of Otto Mears, the "Pathfinder of the San Juan." Beginning with a supply road from Saguache to Nathrop built in 1867, Mears amassed a network of wagon roads and narrow gauge railroads between the mining camps and towns of the San Juan Mountains, eventually controlling more than 383 miles of toll wagon roads. The most famous of Mears' roads was the route between Silverton and Ouray over Red Mountain Pass known as the "Million Dollar Highway." Routed up the Uncompahgre River Canyon south of Ouray in 1878, the road was completed in 1883 after monumental cutting and filling through solid stone at a reported cost of $40,000 per mile.[44]

Other early roads were built and maintained by the stage companies or by the mining communities that they served, but few were of more than minimal quality. There was little incentive to encourage excellence in road construction, and the toll road operators tried to avoid bridge building as an unnecessary expense. The bridges that were built rarely lasted beyond the statutory limits of the franchises. Poorly constructed and unevenly maintained, these rudimentary timber or masonry structures typically washed out in floods or collapsed under load. Ferries also profited at popular river crossings. Charging an average of $1.00 per wagon and team, they provided safer alternatives than fording rivers without bridges. Many later bridges were built at ferry sites. The Black Bridge in Mesa County was built in 1891 at the primary ferry site over the Gunnison River servicing Grand Junction. Similarly, the South Cañon crossing of the Colorado River to the Boston-Colorado Coal Company mines west of Glenwood Springs depended on a ferry for eleven years before the South Cañon Bridge [5GF384] was erected in 1914.

Typically, intrastate travelers of the time had to rely on private ferries or bridges, or they simply encountered no bridges at all and were forced to ford the watercourses. Before about 1890, the bridges that were put up at rural crossings were almost universally timber structures, either stringer bridges on piles or cribs or rudimentary kingpost or queenpost trusses. The Dotsero crossing of the Colorado River was one of the most important in the state, funneling most of the west-bound traffic from Denver through Glenwood Canyon. But despite its pivotal position, the bridge that crossed it consisted of a line of log, kingpost, pony trusses until a steel, two-span Pratt truss was erected here in 1900.

It was not until about 1890 that any concerted bridge building effort by the counties began to appear in the state. If the county seat was situated on a river, the first major bridge usually went up there. One of the first things that newly formed Morgan County did in 1889 was to move the Duell Bridge to the crossing just north of Fort Morgan. It was later replaced by the Rainbow Arch Bridge [5MR471]. Cañon City, county seat of Fremont County, built its first major span over the Arkansas River in the center of town on 9th Street. It soon followed with a second truss, the Fourth Street Bridge [5FN104]. Similar scenarios occurred in La Junta, Lamar and Las Animas in the Arkansas River Valley. Many of the earliest county-built bridges, like those on the toll roads, tended more to the flimsy than the substantial. Some consisted of little more than parallel boards laid across a streambed. Often made up of wood stringer spans on timber piles or crude concrete abutments and piers, these questionable structures failed with distressing regularity. Only a handful proved more permanent. None have survived to the present.

Bridge building in Colorado began to take on real importance at the end of the century. Colorado's population had climbed to 540,000 by 1900 and to over 700,000 ten years later. As steel trusses were more commonly erected over rivers and streams, the state's incipient bridge contracting industry began to grow. The emergence of the automobile at the turn of the century provided a tremendous impetus to county bridge programs. The first car, a Waverly electric, was reportedly introduced in Denver in 1899 by D.W. Brunton. The following year the first Locomobiles were sold in the city, and in 1903 the Denver Chapter of the Colorado Auto Club was founded. As people gained more mobility between towns that had previously been isolated, and, perhaps more importantly, as merchants began to gauge the value of the tourists that streamed into the region in autos and excursion buses, county commissioners felt increasing pressure from their constituents for more and better roads and bridges. The greater tax base from increased population allowed for more ambitious bridge building programs. The first decade of the century marked a dramatic increase in truss building projects in the state. Pin-connected steel trusses, such as the Rifle Bridge [5GF457], the Miner Street Bridge [5CC231] in Idaho Springs, and the Smith Hollow Bridge [5OT794] in Otero County became commonplace products of county-funded programs.

For counties contemplating construction of a major vehicular bridge, the decision was a serious one. Strapped for funds, as most perennially were, the counties could usually afford to fund no more than a half-dozen—and often no more than one—truss per fiscal year. Costing several thousand dollars each, the bridges soon depleted road and bridge budgets. Frequently a county would issue certificates of indebtedness— official IOUs—when it had run out of cash. Or it would delay construction of bridge projects because all of the available funds for the year had been expended. When Mesa County found in 1911 that it could not afford both the Clifton and Main Street bridges despite a special levy approved in 1909, it postponed building the six-span Main Street Bridge, hoping for help from the state legislature, and contracted for the Clifton Bridge that year. The state funding was approved, and the Main Street Bridge was built the following year. Typically, payments to a bridge contractor were the largest line items in a county's expense record, approached in size only by payments to the local bank for retirement of bonds (which may have been issued to fund bridge construction).

Although competitive bidding for bridges was the norm, counties acquired bridges from other sources as well. One feature that the steel truss types shared, and which endeared them to the hearts of penurious county officials, was their versatility. Quickly erected, they could also be dismantled and moved if expedient. Many county bridges in Colorado had begun service as railroad spans, sold or given to the counties after they were no longer functional for the heavier railroad loads. In several instances, not only the bridge but the entire right-of-way was transferred from railway to roadway as entire lines were abandoned. In this way railroad history is merged with highway history, and some of the state's most spectacular railroad spans have been preserved. The Denver, South Park & Pacific narrow gauge railroad between Nathrop and the Alpine Tunnel was laid in 1880-1881 and now serves as State Highway 162/County Road 295A. Located on the line near St. Elmo is the Morley Bridge [5CF1061], the only wrought iron deck truss in the inventory.

Two other abandoned railroads have yielded the state's most striking trestles. The Florence & Cripple Creek Railroad was a narrow gauge line routed through Phantom Canyon to the Cripple Creek gold district in 1894. It was converted to a county road after the closure of the railroad in 1912, leaving two early tunnels and a three-span steel bridge [5FN1704] built in 1894. The Colorado Midland was a standard gauge line that was routed into Aspen in 1888. The Maroon Creek Viaduct [5PT136], a 20-span high trestle just west of Aspen, was built with the original line in 1888 and now is on State Highway 82.

Similarly, early wagon trusses that had become unsuitable to handle increased traffic could be moved to less-traveled crossings. One state bridge that was moved was the Saxton Bridge in Delta County. In 1890 the legislature appropriated $20,000 for a wagon bridge over the Gunnison River near Delta. The state engineer contracted with the Bullen Bridge Company of Pueblo to erect an unequal-two-span Camelback through truss, and the bridge was completed later that year. In 1908 local residents formed a co-op called the Union Bridge Company and engaged Bullen's son to move the trusses to another crossing of the Gunnison near Read. Around 1938 it was reportedly washed out, salvaged, dismantled and moved to sparsely traveled Escalante Canyon. As bridges became obsolete or too deteriorated to save, they were replaced. Many of the bridges in the inventory were second- or third-generation spans, sometimes built over the abutments of previous bridges. Most of the reinforced concrete arches in the inventory have replaced timber or steel trusses. The F Street Bridge [5CF406.75] in Salida and the Huerfano Bridge [5PE3979] in Pueblo County, for example, are both replacement arches built by the Pueblo Bridge Company.

The decision to build a bridge usually would be made in the late spring or summer, after flooding washed away existing timber spans, or in the late autumn, when riverbeds were dry and foundations and falsework could be built economically. The usual procedure was for the county clerk or surveyor to advertise for competitive bids, often giving only the location and span length of the proposed bridge and requiring the contractors to submit their own designs. For cities and counties with a population base to support a staff engineer, the designs were produced in-house, and plans and specifications were issued to competing bridge firms. After solicitation and receipt of proposals, the construction contract was then awarded to the lowest bidder. Separate bids for substructure and superstructure were often given, as were proposals for alternate designs. The Granite Bridge [5CF1091] was built from separate contracts for the bridge and abutments. The tremendous urban viaducts in Denver and Pueblo often involved separate contracts for superstructure, substructure, decking and lighting, and so forth.

When money and circumstances permitted, most or all of the bridges built by a county for the year were let out in a single bidding. Some of the bridges in the inventory, such as the Paonia Bridge [5DT1236] in Delta County, came from multi-bridge contracts. In April 1909 a citizens' committee from the Paonia area petitioned the county board of commissioners for a new bridge to replace the deteriorated existing structure. Although the county waited 2½ years before acting on the petition, in October 1911 the commission solicited competitive proposals for new bridges over the Gunnison at Paonia and Hotchkiss. The county had plans for both structures—Paonia to be a 125-foot truss and Hotchkiss a 150-foot truss—but it also asked that bidders provide schemes for "different styles of construction." At the end of the month the commission received proposals from the state's four principal bridge builders: Charles G. Sheely, M.F. Levy, M.J. Patterson and Fred Bullen's Pueblo Bridge Company. With a bid of $12,990 for both bridges, Pueblo was awarded the contract. By year's end construction had begun, and the Paonia Bridge was completed the following summer.

A typical solicitation for bids in the local newspapers and professional engineering journals would be answered by a handful of national or regional bridge contractors, with an occasional local contractor submitting a proposal. The major steel foundries were in the steel towns of Illinois and Pennsylvania. They supplied rolled steel sections to bridge fabricators such as Hansell-Elcock or the American Bridge Company of Chicago, the Omaha Structural Steel Works of Nebraska, Minneapolis Steel and Machinery Company of Minnesota, or the Denver-based Midwest Steel and Iron Works. The fabricators in turn marketed complete trusses to bridge companies that would erect them on-site. Many of the companies fielded local representatives in the state to keep up with city and county bridge projects.

Among the national and regional firms that bid regularly on Colorado's bridges were the Youngstown Bridge Company of Youngstown, Ohio; the Missouri Valley Bridge & Iron Works of Leavenworth, Kansas; the Wrought Iron Bridge Company of Canton, Ohio; the King Iron Bridge Company of Cleveland; and the Kansas City Bridge Company of Kansas City. In an advertising brochure issued around 1888, for instance, the King Iron Bridge Company listed four bridges that it had erected in Colorado since 1874—125-foot and 150-foot through trusses in Denver and 102-foot and 122-foot through trusses in Pueblo. A similar brochure issued by the Wrought Iron Bridge Company in 1885 also listed four bridges that the company had built since 1874—a 105-foot span in Trinidad, a 50-foot span in Boulder, an 81-foot span in La Porte and a 57-foot span in Golden.[45]

Three major in-state bridge contractors were in constant competition for bridge work during the late 19th and early 20th centuries: M.J. Patterson, Charles G. Sheely and Joseph A. Bullen. Marcus J. Patterson was born in Chatham, Massachusetts, in 1862. After graduating from the Worchester Polytechnic Institute in 1885, he worked as a bridge engineer, first for the Chicago extension of the Santa Fe Railroad and then for the Edge Moor Bridge Company in Wilmington, Delaware. In 1890 he moved to Denver as the local representative for the Lane Bridge Company of Chicago, and in 1895 he formed the M.J. Patterson Bridge Company. In 1900 Patterson was joined by Karl Burghardt, a Minnesota-born engineer who had come to Denver that year after working for the mammoth Gillette-Herzog Iron Works of Minneapolis, the L. Schreiber & Sons Company of Cincinnati, and the Colorado Fuel and Iron Works of Pueblo. Later known as the Patterson-Burghardt Construction Company, the firm designed and erected steel bridges. Patterson-Burghardt also contracted for construction of steel buildings, designing and erecting the steel framework for structures such as the Daniels and Fisher tower in Denver. W.F. Stone described the firm in his 1918 *History of Colorado*:

> They rank with the most prominent in their line in the west, their operations exceeding in volume and importance those of a great majority of firms in the same line in the state. Progressive methods, keen business insight, close application and indefatigable energy on the part of Mr. Patterson have contributed largely to the result achieved.[46]

Among Patterson-Burghardt's more noteworthy commissions were the Lacombe and the Metropolitan buildings in Denver, steel work for the State Capitol and the City Park museum, as well as head frames for several Cripple Creek mines and numerous railroad and vehicular bridges, including the Fruita Bridge [5ME4532].

Like Patterson, Charles G. Sheely designed and erected steel bridges and building superstructures from a Denver base. Not as much is known about his life, however. Born in Redfield, Iowa, in 1871, he formed the Charles G. Sheely Construction Company sometime after moving to Denver around 1905. General contractor for the Gas and Electric Building, he built with reinforced concrete as well as steel and contracted for the Halligan Dam and several road paving projects in Arapahoe and Weld counties. Sheely, who lived in Bear Creek Canyon, also built the highway between Denver and Morrison. He died in 1934 of appendicitis in his winter home in San Antonio, Texas, and is buried in Fort Collins. Several of Sheely's early spans still remain in use and are included in the inventory. The Rifle Bridge [5GF457], a long-span truss erected in 1909, and the Una Bridge [5GF2733], built in 1910 over the Colorado River, are his most outstanding surviving steel bridges. The Una and Lacy bridges in Garfield County proved pivotal to Sheely's career, for it was their structural failures and the ensuing litigation that led to the reorganization of his firm into the Colorado Bridge and Construction Company. Colorado Bridge continued building concrete and steel roadway spans through the 1910s and 1920s. The last major span built by Sheely in Colorado was the Rainbow Arch Bridge [5MR471] in Fort Morgan, the longest Marsh arch bridge in the world at the time of its completion.[47]

The third early Colorado-based company was the oldest and by far the most prolific, involving the careers of founder Joseph A. Bullen and three succeeding generations. Bullen was born in Maine and first came west during the California gold rush of 1849. He returned to the East, moving to St. Paul, Minnesota, where he worked as a surveyor and construction supervisor. Around 1873 Bullen was employed as general superintendent of the Dallas and Wichita Railroad, but the Panic of 1873 forced the closure of the line after only 40 miles of track had been laid. After moving to Leavenworth, he began building a few modest wagon bridges in the eastern part of the state in 1875, and as settlement expanded westward so did his business. In 1884 he formed the Bullen Bridge Company, marking an expansion into other states, including Colorado. In 1887 Bullen erected the first iron bridge in Pueblo, and he moved to that southern Colorado city five years later. From its Colorado base the company began building steel highway bridges throughout the West and Midwest. The Bullen Bridge Company built the first steel bridge over the Willamette River in Oregon in 1893; soon afterward a west coast office of the company was opened in Portland.[48]

After Joseph Bullen's death around 1900, control of the company was assumed by his son, Fredrick H. Bullen. Fred Bullen was born in 1867 in Leavenworth and had worked for his father designing and erecting trusses in the 1880s and 1890s. One of the first things that he did was to change the name of the company to the Pueblo Bridge Company, naming himself as president and H.L. Hollister as secretary. Pueblo Bridge continued at the same pace as its predecessor, putting up steel trusses at a prodigious rate across the West. Fred's son, named Joseph A. Bullen after his grandfather, was born in Pueblo in 1896 and, like his father, began working for the company. In 1913 the younger Bullen opened the Fountain Sand and Gravel Company at the same time the Pueblo Bridge Company was awarded the contract for a major three-span bridge over the Arkansas River at Avondale [5PE300].

Although the Bullens had built reinforced concrete arches using Daniel Luten's patented design as early as the 1907 F Street Bridge [5CF406.75] in Salida, and had consulted with the inventor himself in Pueblo, they were primarily steel truss builders. This new diversification marked the beginning of a subsidiary branch for the company. While Fred dealt primarily with the steel construction, Joseph managed the construction of the arches, and the Pueblo Bridge Company was busier than ever during the 1910s. Both father and son frequently visited with city and county officials around the state, consulting on bridge design and construction and praising the values of the Luten arch. As a result many Luten examples, ranging in span from 54 feet to 100 feet and almost all constructed by Pueblo, are still functioning in the state. The Bullens' hold on bridge building in Colorado was so absolute that in some regions of the state—primarily the south and the Arkansas River Valley—they were virtually the only contractors to put up major spans from 1890 through the 1910s. Today, over two dozen Bullen-built bridges are still standing in Colorado, including the Fourth Street Bridge [5FN104], the oldest Bullen structure in the state; the Butte Valley Bridge [5HF1907] in Huerfano County; the Prowers Bridge [5BN374] in Bent County; the Wolcott Bridge [5EA1614] in Eagle County; the Apishapa Bridge [5OT806] in Otero County; and the three Beulah Bridges [5PE3993, 5PE3994, and 5PE4005] in Pueblo County.

3 Early Bridge Construction by the State

The counties were geared toward road and bridge construction on a local level, but it eventually became apparent to the Colorado State Legislature that broader-based planning was needed as well in order to create a comprehensive network of wagon routes. To augment the counties' civil construction projects, the legislature initiated the Internal Income Fund in 1881. Within the framework of the fund, the legislature could make appropriations for specific projects to improve the state's infrastructure. These could include construction of roads, bridges, irrigation canals and artesian wells, to name a few. Design and supervision of the construction projects was delegated to the State Engineer's Office, also created in 1881. Eugene K. Stimson was appointed the first Colorado State Engineer in June, succeeded by twelve others by 1917.[49] Stimson had little money with which to work and consequently did little. His successor, Edwin Nettleton, was responsible for designing and building the state's first major bridge—a multiple-span, wrought iron truss bridge over the Colorado River in Grand Junction. The Grand Junction Bridge was comprised of five Pratt through trusses supported by stone masonry abutments and piers. Each truss span extended 142 feet, creating an overall bridge length of 740 feet. The state appropriated $25,000 toward construction of the bridge, and Mesa County funded $15,000. The structure was erected in 1886 for a cost of almost $45,000.[50]

Appropriations from the Internal Income Fund grew from a few thousand dollars in the early years to over $340,000 in 1889-1890. That biennium marked the state's first large-scale involvement with road and bridge construction, involving eleven separate projects located primarily on the Western Slope. Included in this work were the Trinidad-Stonewall Wagon Road, which entailed construction of some 40 wooden bridges; combination trusses over the Ten Mile River in Summit County, the Grand (Colorado) River in Eagle County and the Bear River in Routt County; and an immense five-span steel deck truss over the Grand River at Glenwood Springs. During the 1891-1892 biennium, State Engineer James Maxwell erected five more major truss bridges and scores of minor drainage structures built over 170 miles of new roads. Like the counties, the State Engineer's Office contracted for fabrication and construction of these bridges using competitive bidding. The 1890-1891 bridges were built by the major truss manufacturers then working in the state—the Wrought Iron Bridge Company, King Bridge and Manufacturing Company, Missouri Valley Bridge & Iron Works, Bullen Bridge Company and St. Joseph Bridge & Boiler Works.[51]

State Bridges, as they were called, were usually sited at rural crossings. Because they tended to be more substantial than their locally funded counterparts, they became heavily used as regionally important crossings and, in some cases, even created adjacent settlements. The third state bridge funded by the legislature spanned the Colorado River. Budgeted at $6000 in 1889, it was tentatively sited on the existing road at McCoy's Ferry. When the road was found unfit for heavy loads, the site was moved upriver, and the adjoining counties built new roads to it. The construction contract was awarded in February 1890 to the Missouri Valley Bridge and Iron Company. Using wrought iron and native timbers, the company completed a two-span Howe truss in October. The bridge formed a pivotal crossing along the principal east-west route through the center of Colorado, and soon a small community named State Bridge grew around it. Other pivotal state bridges were the Saxton Bridge, built over the Gunnison River in 1890; the Dotsero Bridge, built in 1900; the Hay's Ranch Bridge [5RB2376], 1900; the Fruita Bridge [5ME4532], built in 1907; the Brown's Cañon Bridge [5CF1058], built in 1908; and the San Luis Bridge [5CT141], built in 1911.

Typically, the State Engineer visited the proposed site to take soundings of the river bottom, consulted with the local county commission and county surveyor, prepared construction drawings and specifications, let the project out for bids, awarded the construction contract and supervised the work. Bridge designs from the office tended to be varied, as the engineers experimented with timber, steel and concrete structural configurations. If the cost of the bridge exceeded the state's appropriation, the county was required to make up the difference. Because of the egalitarian nature in the way the legislature distributed projects under the Internal Improvement Fund, the regions of the state outside of Denver, Colorado Springs and Pueblo advanced at similar rates in bridge construction. Among Colorado's counties, Garfield benefitted most from state-funded bridge construction under the State Engineer's Office. State bridges were built at Glenwood Springs (1890), Balzac (1904), Silt (1908), Una (1910), and Lacy (1910 and 1912), totaling almost $120,000 in erection costs.

One outstanding state bridge in southern Colorado was the Costilla Crossing Bridge [5CN909]. Budgeted at $10,000 in 1891, it was to serve as an important crossing over the Rio Grande River between Conejos and Costilla counties. Rather than design the bridge as usual, the State Engineer solicited plans and specifications with the bids from bridge companies. The response was unprecedented: 38 proposals were received from almost all of the major national truss fabricators. In February 1892 the construction contract was awarded to the Wrought Iron Bridge Company of Ohio. Using wrought and cast iron and steel components, the contractor erected a two-span Thacher truss that year. The Thacher design was an unusual one, and WIBCo was apparently the only firm to manufacture all-metal versions of it. As the last unaltered Thacher truss left in America, the Costilla Crossing Bridge is one of Colorado's most technologically significant structures.[52]

Over succeeding years the Internal Improvement Fund grew in popularity, as the counties viewed it as an expedient way to fund much-needed roads and bridges. Individual road, bridge and irrigation projects were selected for funding by the legislature from around the state. Ostensibly chosen on the basis of public need, the projects soon became enmeshed in partisan politics. The program eventually became alternately known as the "Pork Barrel Fund." Hobbled by limited funds and political maneuvering, the state engineer approached road construction tentatively, undertaking only small sections at a time at the direction of the legislature.

By 1899 this strategy had produced mixed results, but the program was still inundated by requests for individual projects. That year the 12th General Assembly was flooded with bills calling for appropriations aggregating three times the amount available. Rather than fund a few well-chosen projects, the legislature chose the politically expedient route, funding them all but reducing the amount of money available to each. This strategy put the legislature and the state engineer at cross purposes: the legislators were seeking to appease a demanding constituency and the state engineer was seeking to craft a comprehensive transportation network. "It is hardly proper to criticize the actions of the legislature in this matter," State Engineer Addison McCune stated, "for this fund is properly regarded as belonging to the entire state, and each district is entitled to such proportion as may be obtainable for the needs of that district." He continued:

> Yet, instead of touching a spot here and there over the state, it would seem wise to plan comprehensive systems of roads in the parts of the state most needing aid, and make appropriations from time to time, as the money became available, for the improvement of certain portions of each system. The improvements thus made would be of much more substantial character. It is not claimed that this plan will appear practicable from the standpoint of the politician, but from the standpoint of an engineer it would be much more satisfactory, and in the end, we think, much better.
>
> Many of the appropriations were entirely inadequate for the work contemplated, but on the theory that a poor road or bridge is better than none at all, the people interested demanded that the money be spent. Nearly all of the road appropriations were for the purpose of repairing or improving existing roads. As there was in no case money enough to rebuild the whole line, the question confronting the different boards of construction [from the individual counties] was how to distribute the work so as to get the most benefit from it. This question was, perhaps, not settled satisfactorily to all parties interested, but the boards of construction in all cases worked conscientiously, and in the main satisfactory results were obtained.
>
> In several instances appropriations were made to repair roads already built by the state and turned over to the various counties with the proviso that the same should be kept in repair by said counties. This action of the

> legislature has been sharply criticized, yet it is better, perhaps, to improve existing roads, if properly located, than to multiply roads in communities that are unable to properly maintain what they already have. This office was considerably handicapped by the fact that at the beginning of the term much of the fund appropriated was not available, so that work had to be taken up in the order in which the bills were approved; this prevented the planning of the work to suit the location, much of the road work, especially, being at high altitude, which prevented the prosecution of it during winter months. This was the cause of many vexatious delays. The high price of steel interfered with the procuring of advantageous contracts during the year 1899, and in one instance a combination bridge had to be accepted, when under a more favorable market the appropriation was sufficient for a steel bridge.[53]

Despite these formative attempts at regional transportation planning, little had changed in the way roads were built in Colorado by the turn of the century. There was no systematic plan for road routing or construction. The state's road system was still a hodge-podge of dissimilar routes, making travel difficult to all but a few destinations. The advent of automobiles and the emergence of the good roads movement at that time, however, provided an impetus for a more methodical approach to road construction. "We do not advocate state control of roads, neither do we advocate the multiplication of our offices," State Engineer E.S. Nettleton wrote in 1902. "We are yet too poor and our country too sparsely settled to enter upon any extravagant or expensive era of road building. But it is believed that some plan might be worked out by which this Department could co-operate with the different counties very profitably and at little expense to the state." Nettleton continued:

> Our present system of flimsy construction, characteristic of all new countries, was especially excusable in a state like ours, having long stretches of uninhabited mountainous country, through which roads had to be built to connect settlements in isolated valleys or mining camps. But we have now advanced sufficiently in wealth and population to inaugurate a new policy. The configuration of the country is such that road systems should be planned out with reference to sections embracing more than one county. Counties should co-operate with each other and with the state in the planning of the main thoroughfares connecting different sections of the state, especially in the mountainous sections.[54]

Others around the state agreed with Nettleton. As early as 1906 a state highway system was being plotted by a group of county commissioners that hoped to coordinate the Internal Income Fund into something more comprehensive and less politicized. The following year the Colorado Association of County Commissioners was formally organized. By 1902 the Colorado Auto Club had been formed in Denver. And by 1905 the first statewide Good Roads Convention had been held. All of this activity served to point out the growing role of automobile transportation and the need within Colorado for a well-maintained highway system. At the 1906 convention of the Good Roads Association, a bill was presented to the legislature that would create a state highway commission. It did not make it far. The 1907 legislature was even less receptive.

In 1908 the Good Roads Association, Colorado Auto Club and the Rocky Mountain Highway Association combined lobbying efforts, and in January 1910 the legislature passed the Taylor Bill establishing the Colorado State Highway Commission. Presumably, the commission would be less politicized than the legislature had been in approving road and bridge construction projects, and it would take a more organized approach to highway planning. James E. Maloney was appointed the first engineer by the governor. Comprised of three members, Maloney and a stenographer, the Commission's first goal was the designation of a statewide road system to link the county seats and more populous towns. It started out by requesting maps from the counties that traced roads within their boundaries and indicated those most heavily traveled. "Many counties did not have any maps; so surveys were necessary," Marion Wiley stated in *The High Road*. "However, 33 counties did send in maps that first year, and the commission established the first system of state primary roads covering 1,643.5 miles." A system in only the most general terms, this loosely knit network was initially comprised of existing roads and streets.[55]

The first of these proto-highways extended from the western edge of Denver to Golden in Jefferson County. Before designating it as State Primary Road No. 1, the Commission first graded and rolled the road over its nine-mile length. The Highway Commissioners designated other routes similarly, first traversing them over their length by automobile before accepting them as state highways. The trips were often arduous, involving impromptu roadwork simply to get the touring car through. One such inspection tour began at the State Capitol on the morning of April 25, 1910. The commissioners motored east on Colfax Avenue out to Watkins, then through Bennett to the Adams County line. They dined with an Adams County commissioner before returning to Denver that night.[56]

Undoubtedly the most difficult of these early excursions took place in the summer of 1910, when the commissioners embarked on a four-week odyssey across the Western Slope. C.P. Allen, T.H. Tulley, J.E. Maloney, and J.C. Allen left Denver early on June 24 and drove through Hartsel, Buena Vista, Granite and Leadville. Two days later they motored over Tennessee Pass "and down west slope past Mitchell into Redcliff for dinner, then past Gilman, Minturn, Allenton, Wolcott, Eagle, Gypsum, River Junction, Shoshone and to Glenwood Springs for the night." From Glenwood they traveled west to Grand Junction. There one of the Allens sprained his knee and was left behind as the others continued southeast through Delta, Montrose, Ridgway, Ouray and Placerville.

On July 4 the men "left Placerville and went to Norwood then around Lone Cove Mtn. by way of Disappointment Creek, stayed at Woods ranch all night, five beds on a porch." The next day, after being pulled over a divide by a horse team, they mired the car in a large mudhole. "Tulley left to hunt teams," their journal noted, "and Carlin and Maloney dug machine out of hole—camped at night by the machine." The touring company then went through Dolores, Cortez, Mancos, Durango, and Silverton. At Durango they had the poor car overhauled before driving east over Wolf Creek Pass, through Pagosa Springs, Alamosa, La Veta and Walsenburg. They returned to Denver on July 20.[57]

That first year the Commission designated 20 state primary roads throughout the state. Three of these first routes formed contiguous legs of the North-South Road that extended along the front range from Trinidad to Fort Collins. State Primary Road No. 2 ran from Denver to Fort Collins (and later extended to the Wyoming state line); State Primary Road No. 3 from Denver to Colorado Springs; and State Primary Road No. 4 from Colorado Springs to Pueblo.[58] During the next biennium State Primary Road No. 26 was designated between Pueblo and the New Mexico state line via Walsenburg and Trinidad.[59]

Other primary roads established in the first year included Road 9, a 112-mile route between Ft. Morgan and the Nebraska state line; Road 11, a 104-mile route between Glenwood Springs and Grand Junction; Road 15, a 145-mile route between Durango and Alamosa; and Road 20, a 140-mile route between Gunnison and the Utah state line.

State Primary Road No. 10 began at Leadville and ran northward, "following the main traveled road to [the] county road over Tennessee Pass, thence down the Eagle river, through Redcliff, Gilman, Minturn, Eagle, Gypsum, Shoshone to Glenwood Springs." Virtually all of these earliest routes were in use before their designation as state roads, and their upkeep still lay in the hands of the counties through which they passed.[60]

The three-man commission undertook its responsibility conscientiously, as stated by Wiley in *The High Road*:

> The first commission accomplished a great deal in spite of its major problem, then as now, inadequate funding for the job that needed to be done. Knowing that good roads are essential to the economic development of a community, the commission was very careful where it allotted its money. Counties were required to match highway funds two-for-one, but more than that, the commission selected carefully those locations where the county agreed to improve standards of design, cutting down steep grades, straightening sharp curves, widening the roadbed, and above all, providing the best possible roadway for use by the greatest number of people. That policy has motivated every highway commission from that day to this. By the end of the year 1910, the commission had allotted $46,500 to counties, spent $9,425.77 for salaries and expenses, and had the entire balance of $74.23 to start the new year.[61]

The Highway Commission immediately addressed the issue of inconsistent bridge construction in the state. Eschewing timber construction as too impermanent, the Commission drew plans and specifications for several reinforced concrete spans. The first two bridges delineated by Maloney were not bridges at all, in the true sense, but rather low water crossings. Essentially multiple-span concrete slabs laid across the streambeds, these structures spanned Kiowa Creek and Box Elder Creek in Adams County on State Primary Road No. 7 between Denver and Fort Morgan. "The Box Elder and Kiowa creek crossings have for years been an eye sore to the ranchers and others living on this main artery to the northeast country," the Commission stated in its first biennial report. The report continued:

> The sand conditions were so bad that a decent load could not be hauled through the creeks without extra teams or an automobile could not get through without animated assistance. As these crossings are over creeks that seldom flow but are subject to heavy floods, concrete flush bridges resting upon wooden piling sunk to the water level, about six feet below surface, were constructed. They much resemble a concrete street crossing, are each four hundred feet long, and cost four thousand dollars for one and thirty-five hundred dollars for the other. Raised bridges would have cost fifteen thousand dollars each and owing to the floods would be in great danger of destruction, whereas the water passes over the flush bridges without any damage or obstruction.[62]

For a crossing of Bijou Creek further up the road, the Commission designed a more conventional concrete deck girder structure, supported by concrete pile foundations.[63] In addition to these three large-scale structures, the Highway Commission also drafted plans for small-scale concrete slab bridges in Douglas, Arapahoe and Montezuma counties. It also reviewed plans for several reinforced concrete bridges in Douglas and El Paso counties that had been produced by Charles G. Sheely.[64]

The next biennium produced embarrassment for the Highway Commission. "The past two years with the State Highway Commission of Colorado have been a series of handicaps and disappointments," Maloney stated in 1912. The state legislature expanded the Commission's discretionary privileges with regard to the construction projects it undertook, but failed to appropriate adequate funds with which to undertake these projects.

Moreover, the authorizing legislation proved to be flawed in its wording. Several counties had undertaken construction projects under the assumption that they would be reimbursed by the state, only to find out that state moneys were not forthcoming. The episode left a bad taste in everyone's mouth, tarnishing the reputation of the Commission.

Despite these problems, the Highway Commission designated an additional 29 state primary roads aggregating 2647 miles. These included State Primary Road No. 22, a 122½-mile route between Colorado Springs and Salida; Road No. 29, an 82¼-mile route between La Junta and Trinidad; Road No. 30, a 176¼-mile route between Colorado Springs and Limon and the state line; Road No. 36, a 170½-mile route from Poncha Pass to Monte Vista; and Road No. 42, a 158-mile route between Rifle and Meeker. The Commission issued bulletins detailing rules for road construction and state road laws, had its first state road map printed by the Clason Map Company of Denver, Colorado, and developed its first bridge standards. Delineating reinforced concrete slab and concrete girder bridges up to 55 feet in span, these drawings were distributed to the counties for use on their bridge construction projects.[65]

The Highway Commission had by this time begun to undertake more widespread bridge design and construction. In 1911-1912 Maloney produced plans for structures of varying size in Delta, Adams, Arapahoe, Morgan, Otero, El Paso, Sedgwick, Rio Grande and Eagle counties. Additionally the Commission funded construction of major concrete bridges over Hogan's Hollow and Steele Hollow on the North-South Road between Pueblo and Colorado Springs. But the largest structure then undertaken by the Commission was a seven-span concrete arch bridge over the Arkansas River at La Junta. Completed in 1914, it was by far the largest bridge built under Highway Commission supervision in its formative years. The state engineer was still building bridges using Internal Improvement funds, but the program was beginning to wind down by this time. The long-span truss over the Colorado River at Una [5GF2733], completed in 1910, was among the last bridges undertaken by the state engineer.

The 1913-1914 biennium marked a continuation of the work from previous years. Up until now the Commission had been poorly funded by the state legislature. It was not until intense lobbying from the Good Roads Association turned the legislature around that budgets began to allow much activity. In 1913 the Highway Act was passed, creating the position of highway commissioner and a five-person advisory board. Funding was changed from a 33:67 match with the counties to 50:50. This allowed the Commission to undertake more ambitious bridge construction projects—including several steel trusses and concrete arches—on the state primary roads. Of these, the Lado Del Rio Bridge [5AA287] in Archuleta County is the earliest traceable example.[66] In April 1914, the Commission issued *Bulletin No. 4*, which detailed standard plans and specifications for several concrete bridge types. Addressed to county commissioners, the bulletin began:

> This bulletin is sent out with the idea of assisting you in the work of road improvements, and the structures incidental hereto. The plans and forms presented are suggestive and, it is hoped, will be of material assistance to all engaged in road work. . . The plans for culverts and bridges are submitted with the view of standardizing as much as possible the construction of these structures. As noted, foundations are of extreme importance and should be most carefully considered.[67]

The bulletin delineated concrete slab bridges with spans ranging from 8 to 20 feet, concrete deck girder bridges with spans from 24 to 52 feet and steel stringer bridges (called "I-beam bridges") for spans between 16 and 32 feet. The steel beams on the latter structures were completely encased in concrete, giving the bridges an all-concrete appearance.[68] The Highway Commission had hoped to standardize bridge construction throughout the state, but the counties were reluctant to adopt the new designs. With their large dependence on reinforced concrete and generally heavy construction, these bridges were more expensive to build than the structures the counties were used to getting from the bridge companies. As a result, state-designed bridges tended to be limited to state-funded roads, and on the other roads the designs varied widely.

During the 1910s automobiles and excursion buses began streaming into the state bearing vacationers to such destinations as Rocky Mountain National Park (est. 1915), Dinosaur National Monument (est. 1915), Colorado National Monument (est. 1911), and mountain resorts around the state. "The results as usual were increased interest in getting more roads," F.L. Bartlett stated in his "History of Road Building in Colorado" in 1918. "Auto travel had increased, other states were sending thousands of autoists into Colorado. Their enthusiasm bid fair to make an endless chain of automobile tourists coming into Colorado to spend the summer months in our scenic mountains." [69] To accommodate this increase in traffic, the Commission by 1916 had designated some 7083 miles of state primary roads.

At this time several counties had begun using convict labor on road projects. "In the past two years there have been five convict camps in operation in this state," the Commission stated in 1917, "most of the time on the construction of the state highways; part of the time on county roads. These camps employ 250 men from the State Penitentiary, and have been successfully worked under the terms of the 'Lewis Law' and under the direction of the Warden, Mr. Thomas J. Tynan, and his Superintendents." Used to varying degrees over the next 30 years, convict labor was used to stretch the construction budgets of the counties. It came at a price, however, as paid laborers complained bitterly about the unfair competition.[70]

The Highway Commission in 1915-1916 built some 275 bridges at an average cost of almost $1000 per bridge. The largest structure undertaken during this time was a 612-foot bridge over the South Platte River at Sterling. The Commission continued its campaign to standardize bridge construction with substantial steel/concrete spans, stating: "Some few bridges were washed out by floods during the past two years. They were all old wooden or combination wood structures that had served their purpose. All that were on the state highways have been replaced with first-class structures of steel and concrete, on good foundations." [71]

During this formative period for the Highway Commission, the federal government was beginning to take a more active role in road and bridge construction as well. In 1912 Congress passed the Post Office Appropriation Act, dedicating $500,000 toward construction of rural roads to facilitate mail delivery. Seventeen states took advantage of this opportunity, resulting in 425 miles of improved roads. This mileage, however, represented only a very small step in the right direction.[72]

Four years later the government took a much larger step, when President Woodrow Wilson signed the Federal Aid Highway Act on July 11, 1916, to usher in a new level of federal commitment to road building. Part of the impetus came from the postal service, which had difficulty delivering mail in many rural areas because of the poor roads. Business leaders also promoted the legislation, citing the need for reliable roads to get farm commodities to market. The legislation was intended to develop an interconnected network of well-built and well-maintained roads throughout the country. Seventy-five million dollars were initially available to states, apportioned by a ratio based on area, population and miles of rural postal roads. Matched dollar-for-dollar by the states, the allotments could be used only on projects approved by the U.S. Bureau of Public Roads [BPR], predecessor to today's Federal Highway Administration. Expenditures could not exceed $10,000 per mile, exclusive of bridge costs. The latter were paid by counties, sometimes with state assistance. Federal funds were to be used on rural roads, or on roads in communities with under 2500 residents, but they could not be used on projects involving convict labor.

The act stipulated certain organizational requirements for state highway departments. As one of 15 states that did not initially comply with these requirements, Colorado was compelled to restructure its highway commission. In 1917 the legislature passed the Highway Act, which transformed the Colorado Highway Commission into the Colorado Highway Department (CHD). Wiley describes the functional changes involved in this:

> The commissioner remained in office under the same title. However, the five-man Advisory Board was changed to a five-man Highway Commission. This time the duties were to be responsible for general overall supervision of the department through the commissioner. State routes were defined as any road in the state open for public use, and state highways were those designated by the commission as a part of the state system to be first improved. The commission could add to or delete from the system and was responsible for preparing an annual department budget for approval by the governor. This covered all construction projects for the year as well as all salaries and other expenses. Meetings during the course of the year permitted the adjustment of projects as conditions warranted. Fundamentally, except for the number of commissioners, this is the same general organizational structure that exists today.[73]

With the funding mechanism now in place, the state could receive federal aid grants from the Bureau of Public Roads. On December 6, 1917, the Highway Department designated its first six federal aid projects. Federal Aid Project No. 1 involved construction of almost four miles of concrete paving on Santa Fe Drive between Denver and Littleton. Under the first direct agreement executed between CHD and a private contractor, Charles Connor of Denver began the work in December 1917 and completed the project the following November. Federal Aid Project 2 involved construction of the North-and-South Highway between Pueblo and Trinidad in Pueblo and Las Animas counties. Covering almost 65 miles, the work was divided for administrative purposes into several shorter segments and let under separate contracts.

The other four projects included work on State Primary Road No. 17 between Granite and Twin Lakes, on Road No. 42 between Rifle and Meeker, on Road No. 44 between Placerville and Norwood, and on Road No. 34 between Lamar and Springfield. All of these early projects involved roadway building and construction of minor drainage structures—primarily concrete culverts and small-scale slab or girder bridges. The first federal aid project developed specifically for bridge construction was FAP 41, which involved construction of a bridge over the South Platte River on Road No. 9 between Sterling and Merino.[74]

As these first projects were underway in the 1910s, the Highway Department refined its standard bridge designs for use on state and county roads. The Department continued its support for concrete over timber for bridge construction, publishing photographs of concrete bridges that replaced earlier timber structures in its house magazine, *Colorado Highways Bulletin*. "Thousands of dollars will be lost to the state this year as a result of the faulty construction of bridges in the past," CHD stated in a July 1918 article entitled "Rigid Standards Needed in Good Bridge Construction." "The abnormally high waters of the Arkansas , Gunnison and Grand Rivers have swept out many bridges which must be replaced without delay and in many instances the loss is due to economy in construction where the expenditure of comparatively small additional sums would have served to obviate danger of washouts." The article concluded: "It is poor economy to build a bridge which is inadequate in any of these respects and we should have a law requiring that all bridges and culverts should be built in conformity to a rigid standard design with plans and specifications to fit each location." [75]

In November 1919 CHD published standard designs for concrete slab bridges with spans ranging from 8 to 20 feet. The designs featured concrete post-and-beam guardrails and arched haunches where the slab joined with the abutments. "The form work for this type [of bridge] is simple in construction; the reinforcement of square twisted steel. The steel is generally available from stock material." James Maloney, whose title was by this time State Chief Engineer, also delineated standard plans for similarly detailed concrete girder and steel I-beam stringer bridges. Among the first bridges to use these designs were the two-span Bear Creek Bridge [5JF2303] in Jefferson County and two small-scale structures on State Primary Road No. 32 in Lincoln County. Spanning Coon Creek [5LN271] and School House Gulch [5LN275], these latter structures featured concrete deck girder superstructures, supported by concrete abutments with angled wingwalls.[76]

Slowly, bridge construction in Colorado began to take on a 20th century character, as timber trusses and trestles built in the 19th century were replaced with more substantial concrete/steel structures. The Highway Department was gradually taking control of the state's roads, a process that was accelerated in 1920 and 1922, when voters approved $5 million and $6 million bond issues to match federal construction funds. Two events in 1921—one natural, the other man-made—changed the complexion of bridge construction in the state. The first occurred on the night of June 3, 1921, when floodwaters roared down the Arkansas and St. Charles rivers and their tributary streams throughout Pueblo County. A wall of water some 13 feet high swept through Pueblo's downtown, killing almost 300 people and causing $10 million in property damage in Pueblo and an additional $15 million in damage further down along the Arkansas River to the state line. Most of the existing vehicular and railroad bridges in the county and virtually all of the major bridges in the city were severely damaged, destroyed or washed away completely. "When dawn streaked the eastern skies on the morning of June 4, 1921, Puebloans saw human lives and property drifting down the mile-wide stream of thick, muddy waters of the Arkansas," *Pueblo Star-Journal* staff writer Ralph Taylor reported. "While the nightmare of a dozen uncontrollable fires lighted up the vast stream of destruction which was filled with screaming and terror-stricken men, women and children, man became serious as never before. It was unanimously agreed that the Pueblo flood should never recur." [77]

The city quickly began to regroup and consider an appropriate course of action. "Pueblo's great flood throws upon the people of this city the necessity of rebuilding about one-seventh of its present area," the *Pueblo Chieftain* stated. "The choice lies between indefinite and purposeless reconstruction and building in accordance with a definite purpose and plan." In September the city council hired the Dayton Morgan Engineering Company of Dayton, Ohio, to prepare a comprehensive study of flood control measures. That winter the city undertook stopgap repairs while the studies were underway.

The extent of flood damage to Pueblo was well beyond the city's means to repair, so in April 1922 Colorado Governor Oliver Shoup convened a special session of the state legislature to plot the state's participation in the relief efforts. The legislature approved the establishment of the Pueblo Conservancy District to build an extensive flood control system in and around Pueblo. As a sop to constituents in the northern part of the state, the legislature also approved construction of the Moffat Tunnel, a project that had previously failed to win funding—in large part due to the protestations of constituents in the Southern part of the state. Despite vocal opposition against the Conservancy District and the flood control strategy, plans continued for its implementation. In March 1923 Dayton Morgan issued its "Official Plan" for flood control, which called for extensive channelization of the river in a concrete-lined canal. Under Morgan's plan, the bridges destroyed by the flood would be reconstructed over the new channel.[78]

Pueblo County was in much the same fix as the city. Lacking the financial resources to rebuild the ruined structures all at once, the county undertook their reconstruction one-by-one over the next three years. With $160,000 of federal aid funds diverted by the state for the project, the county soon began rebuilding bridges. According to Taylor:

> Bridges to weather the wrath of floods, substantial structures which cannot be undermined and which afford an abundance of clearance, has been the aim of county and state officials in the rebuilding program. To accomplish this, longer bridges with as few spans as possible have been erected. Suspension bridges were considered, but none have been built, largely because contractors could not be found who would bid on that type of work.[79]

By 1925 almost all of the major bridges in the county had been replaced. Included in the massive reconstruction project were the Santa Fe Avenue Bridge [5PE3938], a long-span steel truss over the Arkansas River in downtown Pueblo; the Union Avenue Viaduct [5PE822], a combination steel truss/concrete viaduct structure; the Eleventh Street Bridge [5PE4016], an unusual hybrid bridge built onto the side of an adjacent railroad structure; the Huerfano Bridge [5PE3979], a five-span concrete arch bridge which was billed as the longest concrete bridge in the state; the St. Charles Bridge [5PE301] and Nicholson Bridge [5PE4011], both massive, three-span concrete Luten arches; and the Nyberg Bridge [5PE4003], a long-span steel truss over the Arkansas River. The result of all of this construction was that the city and county of Pueblo were served by a series of modern concrete/steel bridges where an uneven accumulation of timber, iron and steel structures had once stood. It represented the first such comprehensive bridge replacement effort in Colorado.

The second event in 1921, though less reported in the newspapers, had a more wide-reaching effect on the state. That year the legislature passed the Highway Act, again reorganizing the Highway Department to conform with BPR policy. Major L.D. Blauvelt was appointed the State Highway Engineer in May, and a month later R.H. Higgins was picked to head the newly created maintenance division. Creation of this latter division was critical to the state's highway development. Heretofore CHD had been responsible for road construction only; subsequent maintenance remained under the purview of the individual counties, and the roads were accurately considered to be county roads, despite their designation as state primary roads. The 1921 law placed Colorado's roads under the continued supervision of the State Highway Department. The result was that Colorado for the first time could be said to have a state highway system. CHD began building a bureaucracy to handle the newly delegated responsibilities. According to Wiley:

> An engineering division was established under the supervision of the assistant highway engineer. Highway location crews were set up to make the initial surveys. Crews were assigned to make the final engineering surveys, obtaining the necessary field data, with the headquarters engineering division preparing construction plans and specifications in order to bridge the project to contract. Later on, division engineers were stationed

> at various locations over the state, but until then, all work was supervised directly from Denver headquarters. in remote areas had to use their own judgment, resourcefulness, and ingenuity as a matter of necessity.[80]

With its new responsibilities and its new organization, the Highway Department spent the 1920s consolidating the state's patchwork road system into an integrated network of graded and paved highways. Many of these functioned as transcontinental routes, as discussed in the next section. By 1922 the state had a total of 48,000 miles of roads, 8,135 of which had been designated as state primary roads under the aegis of CHD. Of those, about 1,100 miles had been improved to some extent, and an additional 220 miles were under construction.[81]

In 1925-1926 the Highway Department undertook its first bridge inventory, listing all of the structures in the state and giving their structural description. "To date 1,250 structures have been located," CHD bridge engineer Paul Bailey reported in January 1926, "and it is estimated there are from 1,800 to 2,000 bridges in use over the state of twenty-foot span or greater. At first glance, this seems a high number but when you remember that the State, known as the "Mother of Western Rivers," has probably the largest number of tributary streams of any state in the union, it does not seem so high." [82]

The 1921 Highway Act stipulated that the State Highway Department was to furnish designs to the counties for bridges over 20 feet in length, when requested. In addition to designing bridges on its own highways, therefore, the Department offered design services to the counties for their secondary road structures. "The bridge department wishes to co-operate with the counties in their bridge construction," CHD bridge engineer R.S. DuBois stated in 1923. "It offers to the counties its services in all phases of bridge design, repair and strengthening. It will prepare plans for a structure, or will examine a proposed plan, report upon the adequacy of the design shown, and note any changes in design when modification is considered preferable, or will inspect existing bridges and report upon repairs or alterations considered advisable, or estimate quantities of material involved, and prepare estimates of the cost of construction." The legislature had made it clear that the Highway Department's role on county-built bridges was at the discretion of the counties. The records do not indicate the extent to which the counties availed themselves of this service, but it is clear that compliance with state bridge standards varied considerably from county to county.[83]

During the 1920s the Highway Department continued to upgrade its standard bridge designs. Since introducing them in the 1910s, the agency had occasionally updated its plans for box culverts, concrete slabs and girders and steel I-beam stringers to reflect the changing standards of the Bureau of Public Roads and the American Association of State Highway Officials. These changes generally involved wider roadway widths and heavier carrying capacities. Reflective of CHD bridge design policy of the 1920s, most of the Department's bridges that remain intact from this formative period employ standard concrete or steel beam designs. These include such noteworthy structures as the Graneros Creek Bridge [5PE4012], Muddy Creek Bridge [5PE4013] and Gonzales Canyon Bridge [5LA8094], all three-span concrete girder bridges built in the mid-1920s in Pueblo and Las Animas counties; the Spring Creek Bridge [5KC168], a multiple-span concrete girder bridge in Kit Carson County; the South Platte River Bridge [5PA1250], a two-span concrete girder bridge in Park County; the Bear Creek Bridge [5FN1689], a four-span concrete slab bridge in Fremont County; and the West Salt Wash Bridge [5ME11846], a six-span steel stringer bridge in Mesa County.

During the 1920s the Department introduced standard designs for rigid-connected Pratt through trusses, ranging from 100 to 140 feet in length. Four of these early trusses remain in place today: the Timpas Bridge [5OT803] in Otero County, the Hardwick Bridge [5GF2734] in Garfield County and the two Gunnison River Bridges [5GN3321 and 5GN3322] in Gunnison County. CHD also experimented briefly with a Parker pony truss configuration in the mid-

1920s, building a handful of these long-span trusses before adopting the rigid-connected Camelback as its standard pony truss. Two of these early Parkers remain in use: the Slate Creek Bridge [5ST324] and the Beaver Creek Bridge [5FN1710] in Fremont County. At this time CHD developed standards for long-span Parker through trusses with rigid connections. In 1922-1923 it erected its first Parkers over the Rio Grande River near Monte Vista, over the Arkansas River at Las Animas, and over Fountain Creek at Buttes, south of the town of Fountain. Several examples of standard-plan Parker trusses can still be found, including the two Eagle River Bridges [5EA1590 and 5EA1608] in Eagle County, the Black Squirrel Creek Bridge [5EP3561] in El Paso County, and the Colorado River Bridge [5ME11803] in Mesa County.

During the 1920s the Highway Department also experimented briefly with cantilevered concrete girder construction, building several of these long-span structures for bridges and grade separations. Four of these distinctive bridges remain in place: the Raton Creek Bridge [5LA8188] and the C&S Railroad Overpass [5LA8185] in Las Animas County, the Cottonwood Creek Bridge [5EP972] in El Paso County, and the Rio Grande Railroad Viaduct [5FN1693] in Fremont County. In addition to its standard-plan bridges, CHD built a small number of singular designs in both concrete and steel. These include the Sapinero Arch, a long-span steel deck arch bridge; and the Huerfano Bridge [5PE3979], a multiple-span concrete arch bridge. For both its standard and custom designs, the Department generally used simply supported spans with well-tested superstructural types. Even such continuously supported structural types as cantilevered girders and rigid frames followed industry standards developed elsewhere. The ingenuity attributed by Wiley to the Department apparently did not extend to bridge engineering. In fact, little in the way of structural innovation could be credited to CHD during the next 20 years.[84]

4 Early Transcontinental Highways

The search for an east-west overland route through the central Rocky Mountains has provided a defining theme throughout Colorado history. The Rockies extend through the state from north to south in a high, wide band, presenting what historian Robert Ormes has called a "geographical irony." Mineral wealth resided in the mountains, drawing prospectors and populating the territory. At the same time the forbidding terrain, steep canyons, deep river gorges and rough, rocky landscape thwarted many early efforts to build wagon roads and railroads through the mountains.[85]

Beginning with the 19th century stage routes, and continuing with the first transcontinental railroad and the first transcontinental highway, transcontinental travel has played a defining role in Colorado transportation The first regional route to enter the state was the Santa Fe Trail, which cut across the extreme southeastern corner of what would become Colorado. As discussed in an earlier section, other trails such as the Overland Trail, the Smoky Hill Trail and the Cherokee Trail eventually stretched across the state. Wagon caravans traversing these early routes undertook their own road improvements and forded the rivers and streams that they encountered along the way. When the rivers were flooded, they simply waited for the waters to subside before attempting the crossing.

When surveyors ranged westward in the 1850s searching for a route for a transcontinental railroad, they concluded that a railroad could be built through the Colorado Rockies only via a difficult, circuitous route and by blasting at least one major tunnel beneath the Continental Divide. When the Union Pacific began actual construction of the transcontinental line in the 1860s, it dispatched its own surveyors to Colorado. They too failed to find a suitable course through the mountains. By early 1867 UP directors reported to the Secretary of the Interior that "the topography of this mountainous region forbids the passage of this national thoroughfare directly through the mining regions of Colorado." The Union Pacific instead routed the line through southern Wyoming to avoid the precipitous mountain range, to the everlasting dismay of Denver businessmen.[86]

Being bypassed by the Union Pacific was a major blow to Colorado, but other railroads soon sprang up to fill the void. The most significant of these early Colorado lines was the Denver & Rio Grande, established by General William Palmer in 1870. Using an innovative three-foot-wide track gauge, the D&RG built aggressively through the Colorado mountains to serve such booming mining towns as Aspen, Creede and Leadville, with the ultimate goal to forge a transcontinental link that would pass through Colorado. The Rio Grande built tracks to Leadville in 1880. From here tracklayers continued northward to the mining districts at Tennessee Pass and Redcliff. By the end of 1881 they had passed through Redcliff, laying track along each side of the Eagle River to its confluence with the Grand River at Dotsero. Called the Eagle River Extension, this route was well suited to railroad construction. Not only was the Eagle River Valley relatively broad and straight—in mountain terms, anyway—but its gradient was among the gentlest of Palmer's narrow-gauge mountain lines.[87]

As often happened, the Eagle River Extension had followed the route of an earlier wagon road. In mountainous terrain wagon roads were more quickly and more easily constructed than railroads. They could be snaked through rugged canyons and routed over passes using grades impossible for trains to make. As a result, an impromptu network of overland roads developed in the 19th century to link those mining towns in the Colorado mountains that the railroads could not reach. The railroads that were built often followed directly over or close to the rights-of-way of preceding wagon roads.

On May 3, 1899, the 12th General Assembly approved Senate Bill No. 1, which established a road across the state from Denver to Grand Junction. According to the act, "the most practicable route and the more definite location of said road and the branches thereof along the general course above indicated shall be determined by the State Engineer, and which route shall, so far as practicable, be along the lines of regularly established and existing county roads." The first east-west route designated by the state, its routing was determined by a board comprised of the governor, the state engineer and commissioners of the counties through which it passed. The road would generally follow the D&RG's Eagle River Extension over Tennessee Pass and along the river through Redcliff, Wolcott, Eagle and Gypsum to the river's mouth at Dotsero.[88]

In 1900 the state engineer's office erected a two-span steel bridge to carry the Denver-Grand Junction Road over the Colorado River at Dotsero. Three years later the state contracted for 20 miles of grading on the road in Mesa County. And in 1905 the legislature directed additional construction in sections between Tennessee Pass and DeBeque. In response to this last appropriation, State Engineer T.W. Jaycox toured the route with commissioners of Eagle and Garfield counties in May 1906. "As a result of the trip of inspection," Jaycox later reported, "it was decided to use the money in [seven separate] places." Sections of the road would be improved near Hawley's Ranch in Eagle County: two miles east of Minturn; five miles east of Eagle at Ortega Siding; six miles west of Glenwood Springs at Hell Gate; and at Webster Hill six miles west of Rifle. Additionally, a concrete bridge would be built at Cañon Creek eight miles west of Glenwood Springs. The state let contracts for the construction in August; by the end of the year work was complete. In October 1910 the state contracted for additional roadwork on three sections in Eagle County, costing $7,500.[89]

That year the State Highway Commission designated the Eagle Valley Road as State Primary Road No. 10. "Starting from the northern city limits of Leadville," its description read, "and following the main traveled road to [the] county road over Tennessee Pass, thence down the Eagle river, through Redcliff, Gilman, Minturn, Eagle, Gypsum and Shoshone to Glenwood Springs." State Primary Road 10 thus incorporated part of the earlier Denver-Grand Junction Road, which had followed the Eagle County road, which, in turn, had started out as a private toll road.[90]

Although the focus of these early trails and roads was primarily east-west, none was more important to Colorado's development than the north-south route that stretched along the front range. Called the Great North and South Highway, it linked many of the state's most important cities—Fort Collins, Denver, Colorado Springs, Pueblo, Trinidad—along a single strand from New Mexico to Wyoming. The origins of this road are obscure. Undoubtedly sections of it were in use during initial settlement of the territory in the early 1860s; Colorado's first stage line began operating on the road between Denver and Pueblo as early as 1862. The North-South Road—particularly the stretch from Denver south to Colorado Springs and Pueblo—was already under heavy usage when the state legislature established the Internal Income Fund in 1881. During the 19th century, the state engineer did little to improve this route, because, compared with the poor state of road construction elsewhere in Colorado, it was in relatively good condition.[91]

The North-South Road had up until then been developed on a piecemeal basis as a series of separate segments. Little had been done either by the state or by the individual counties and municipalities to coordinate construction and maintenance efforts. This began to change in 1907, when the state legislature authorized "the construction of a highway beginning at the southern boundary of the state and running north through Trinidad, Walsenburg, Pueblo, Colorado Springs, Denver, Longmont, Loveland and Fort Collins to the Wyoming line." As stipulated in the act, the state engineer was responsible for locating and surveying the road, designing it, approving plans for all bridges on it, and supervising its construction. The legislature ordered the road built by convict labor and appropriated $10,000 to defray the costs for equipment and extra men to guard the prisoners.[92]

In March 1908 the commissioners for the counties through which the road would extend met to plan its construction. They agreed that work should begin at the south end near Trinidad and progress northward in stages. A surveying crew began fieldwork on April 1, and actual construction began on May 13. Las Animas County supplied the materials for road and bridge construction; the convicts supplied the labor. When funds from the original appropriation ran out on September 7, Trinidad businessmen were able to keep the work going with private subscriptions of money. Although this initial construction addressed only a small portion of the road in Las Animas County, State Engineer Thomas W. Jaycox judged the project a success. "Aside from the moral and physical influence upon the convicts of an out of door life," he stated, "under a camp managed entirely on the honor system, and the advertising which this State is receiving on this account throughout the country, it would appear that the experiment has been a very successful one." This work was completed by the end of 1908.[93]

The following year the legislature mandated further improvements on the highway—this time authorizing "construction of a driveway from the south side of the limits of the City and County of Denver to the north side of the limits of Colorado Springs." After consulting with the El Paso County Commissioners, State Engineer Charles Comstock divided the work into seven relatively short sections between Colorado Springs and Palmer Lake. The construction was completed by the end of 1910 for a cost of $18,000, which was divided equally between the state and the county. That year the state engineer spent an additional $3,500 repairing the existing wagon road between Loveland and Fort Collins.[94]

When the State Highway Commission first began designating state primary routes in 1910, three of the first routes formed contiguous legs of the North-South Road. State Primary Road No. 2 ran from Denver to Fort Collins (and later extended to the Wyoming state line); State Primary Road No. 3 from Denver to Colorado Springs; and State Primary Road No. 4 from Colorado Springs to Pueblo.[95] During the next biennium State Primary Road No. 26 was designated between Pueblo and the New Mexico state line via Walsenburg and Trinidad.[96] During the 1910s the Highway Commission funded incremental improvements to both the east-west and the north-south highways. Eagle County built substantial concrete arch bridges over the Eagle River at Sherwood Ranch [5EA1631] in 1912, at Gypsum [5EA1628] in 1914 and at Wolcott [5EA1614] in 1916.[97] Douglas and El Paso counties soon began improving their sections of the Denver-Colorado Springs road as well. The roadway here was graded and rerouted in a few troublesome spots, and eight small concrete bridges were built. "We have been highly complimented on the changes effected in this road," the Commission reported in 1911, "such as overcoming excessive grades and abolishing curves."[98]

In 1913 the Commission could report: "On the Great North and South Highway, Larimer, Boulder, Arapahoe, El Paso, Pueblo, and Las Animas Counties have done a great deal of work in road- and bridge-building during the past two years."[99] Four years later the Commission listed additional highway improvements:

> The North and South Highway runs from Cheyenne, Wyoming, through Fort Collins, Loveland, Longmont, Denver, Littleton, Castle Rock, Palmer Lake, Monument, Colorado Springs, Pueblo, Walsenburg and Trinidad, to Raton, New Mexico. The road was graded, surfaced and has permanent bridges for 266 miles of the entire 326 miles within Colorado. Larimer, Boulder, Adams, Arapahoe, Douglas, El Paso and Pueblo Counties have this road surfaced. Huerfano has finished a fine concrete bridge over the Huerfano River and graded part of their road, and Las Animas County has built a number of concrete culverts and bridges and surfaced a portion of the road. There remains about 60 miles to be surfaced.[100]

The Commission began using the North-South Road as the principal trunk line through the state, to which east-west feeder routes would be connected. Although Colorado actively lobbied to have national east-west highways routed through the state, in truth the North-South Road formed a more authentic interstate highway.

Most of the pressure for highways into and through Colorado came from the east, not the south. Some 2.5 million miles of roadway had been laid in the country, but less than 7 percent of these had been improved by grading or graveling. Only a few hundred miles had been paved with bricks, and concrete was as yet untested as a construction material. Moreover, the roads that did exist lacked any coordination from state to state or even from county to county. With the number of automobiles growing geometrically and their drivers becoming increasingly more adventurous, the transcontinental route was an idea whose time had come.[101]

During the 1910s several quasi-public organizations formed to promote specific transcontinental or trans-regional routes. The first of these to affect Colorado was established in 1911. That May representatives from towns along the Chicago, Burlington & Quincy Railroad in Nebraska and northeastern Colorado met in Holdrege, Nebraska, to discuss the formation of a regional highway between Omaha and Denver. They named their group the Omaha-Denver Transcontinental Route Association and the highway the Omaha-Lincoln-Denver, or OLD Highway. To garner publicity for the new road, they organized a caravan from Omaha to Denver that summer. Joining the group was H.E. Huebinger of the Iowa Publishing Company, who was under contract to write a guidebook for the highway.

The caravan traveled at a leisurely pace, taking 10 days to travel the 632-mile route. "The first survey of a continuous highway between the Missouri River and the Rocky Mountains, for the sole purpose of promoting vehicle travel between the two points, was completed yesterday afternoon," the *Denver Post* reported on July 27, 1911. Historian Carol Ahlgren described the trip: "At towns and rural stops along the way, the automobiles were greeted by waving crowds, local bands, and Main Streets decorated for the occasion. Association members gave speeches about the importance of good roads and the OLD, which they claimed was the road to take to Denver, 'no matter how one has reached Omaha or Lincoln.'"[102]

A year later Carl Fisher, founder of the Prest-O-Light headlight company, began boosting what he called the Coast-to-Coast Rock Highway, a continuous line that extended from New York to San Francisco. In September 1912 Fisher sponsored a banquet for members of the Indianapolis auto industry to solicit help and money for his project. 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 highways of America," Fisher enthused, "are built chiefly of politics, whereas the proper material is crushed rock or concrete." The response was immediate. Goodyear president Frank 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.[103]

In 1913 Fisher organized the "Hoosier Tour," which, like the OLD tour two years before, would ostensibly follow the general route of the proposed road. Although Fisher was careful to differentiate the Hoosier Tour from the actual highway route, he all but promised the governors of Colorado and Kansas that his new highway would pass through their states. According to Lincoln Highway historian Drake Hokanson:

> Fisher was under considerable pressure to decree the highway route to be the same as the route of the Hoosier Tour, what with banquets, speeches, free gasoline, promises of great road improvement, and strong hand-shakes from Governors Hodges of Kansas and Ammons of Colorado. Carl Fisher even supported the formation of Lincoln Highway booster clubs in the towns they passed through. How enthusiastic would people have been for this highway if they didn't believe that it would pass through their towns? By this time the pressure to select the route was so great that almost everyone, including Carl Fisher, believed or wanted to believe that the Hoosier Tour was laying out the Lincoln Highway.[104]

Responsibility for actual mapping of the highway fell not to Fisher but to Henry B. Joy, president of the Packard auto company. Joy remembered an earlier trip across Colorado in which the car barely made it over Berthoud Pass. With Denver as its western terminus, the OLD Highway did not have to contend with the Rocky Mountains, but organizers of the Lincoln Highway were gravely concerned about the prospect of crossing the Continental Divide on the way to San Francisco. To the bitter dismay of Coloradans, Joy elected to follow the original transcontinental railroad across southern Wyoming to avoid Colorado's Rockies. As a sop to Governor Ammons, the Association agreed to dogleg the highway from Big Springs, Nebraska, along the OLD route to Denver, and back up to Cheyenne. The gerrymandered route added considerable mileage to the highway, however, and it was quietly dropped by the Highway Association in subsequent years.

The disappointment of being bypassed by a transcontinental highway lingered, and Colorado had to content itself with the original OLD road, which had by then been renamed the DLD for Detroit-Lincoln-Denver. In 1910 the Colorado Highway Commission had designated the route between Julesburg and Ft. Morgan as State Primary Road No. 9. During the next biennium it established the route between Sterling and Holyoke, where the original OLD branched eastward from the South Platte River, as Primary Road 23. The Lincoln Highway subsequently pulled much of the traffic from the DLD in western Nebraska, and as a result, the principal entrance into Colorado from this direction became Julesburg, not Holyoke.

Several other privately designated, sometimes overlapping highways soon sprang up. By 1922 eight other transcontinental highways had been routed across America, including the Theodore Roosevelt International Highway between Portland, Maine, and Portland, Oregon; the Yellowstone Trail between Boston and Seattle; the Bankhead Highway between Washington, D.C., and San Diego; and the Old Spanish Trail between St. Augustine and San Diego. Four of these routes crossed Colorado. Formed immediately after the debacle of the Hoosier Tour, the Midland Trail crossed Colorado and Kansas on its way between Washington, D.C., and Los Angeles. The Midland did not follow a single line through the state, however. It entered Colorado at Burlington and ran westward along State Primary Road No. 30 to Colorado Springs. There it split into at least three different routes through the mountains and left the state on Primary Roads 11 and 41 and a road that had not even been designated by the Highway Commission.

The Pikes Peak Ocean-to-Ocean Highway also crossed Colorado on its way between New York and Los Angeles. It generally followed the Mountain Branch of the Santa Fe Trail through Colorado to Colorado Springs, where it followed the Midland's central route through Leadville, Wolcott, Glenwood Springs and Meeker on its way to the Utah state line. The National Old Trails Road crossed the southern part of the state on its way from Baltimore to Los Angeles. Entering Colorado at Holly, it followed the Arkansas River Valley through La Junta, Pueblo, Cañon City, and paralleled one of the Midland's branches west out of the state.[105]

The last transcontinental road was the Victory Highway, which like the Lincoln extended from New York to San Francisco. Named to memorialize the veterans of World War I, it too crossed over Colorado's central mountains. "Across Colorado, the Victory Highway essays the Continental Divide over Berthoud and Rabbit Ear passes on a government built road which supplies a wide and safe line of easy grade through the most inspiring scenery to be found on any cross country highways topping a region between Denver and Salt Lake." The Victory Highway competed directly with the Lincoln for usage. "It is the shortest line across, the most scenic and supplies today the maximum of pavement," stated Ben Blow, vice-president of the Victory Highway Association. "It has been selected as the only New York-San Francisco line which will be developed in its entirety by Federal Aid, and passing through the heart of America in the grain fields of Kansas it ties the east and west together into that unity of interest which is only to be achieved when barriers of nature are conquered by the engineers' transit and travel may flow back and forth over good roads."[106] Other, lesser routes such as the Utah and Colorado Transcontinental Route enjoyed brief popularity in the 1910s, but it was the Lincoln Highway that still carried most of the traffic into Colorado from the east.

None of these highway organizations had the financial wherewithal to undertake actual large-scale construction, however. Road and bridge construction in Colorado was still the responsibility of the state and the counties in the 1910s. In October 1922 the Bureau of Public Roads approved Colorado's federal aid system. Using the BPR's seven-percent rule, the state was allowed to designate 3360 miles as federal aid highways from its total of 48,000 miles of roads. At this time CHD changed the designation of the routes from state primary roads to state highways. These were renumbered loosely on the basis of relative importance to state transportation. Under the new system the North-and-South Highway became Colorado State Highway 1. The Lincoln Highway between Denver and Julesburg was renumbered State Highway 2; this was extended beyond Denver westward into the mountains through Hot Sulphur Springs, Steamboat Springs, and Craig to the Utah state line. The road from Greeley north to Cheyenne was designated State Highway 3. State Highway 4 was the old east-west road formed by the legislature in 1899. It started at Burlington on the Kansas state line and ran through Limon, Colorado Springs, Buena Vista, Leadville, Eagle, Glenwood Springs and Grand Junction to the Utah state line. State Highway 5 was a short spur route that connected Highways 1 and 3 through Carr. And State Highway 6 followed the National Old Trails Road from Holly to Pueblo and into the mountains through Salida, Gunnison, Montrose, Delta and Grand Junction.

Designation of state highways served to integrate Colorado's road system, but it did little to tie the state's roads with those of adjacent states. This problem was national in scope, begging for a national system of highway numbering. In 1924 the American Association of State Highway Officials Committee on Administration began working on just such a system. Late the following year the Secretary of Agriculture approved the new system. Under this plan east-west highways would be given even-numbered designations; north-south highways, odd-numbered. Diagonal highways would receive special designations. In Colorado State Highway 1 became U.S. Highway 85 between Trinidad and Denver and 285 north of Denver. State Highways 2 and 3 between Denver and the Wyoming state line became U.S. 85. U.S. Highway 40, which extended east-west across the state, was divided like the old Midland Trail into north and south branches. The north branch followed State Highway 4 from the Kansas state line to Denver and then State Highway 2 over the mountains to Craig. U.S. Highway 40 South followed State Highway 8 from Cheyenne Wells to Colorado Springs and then State Highway 4 over the mountains to Grand Junction. State Highway 50 followed the old Santa Fe Trail from Holly to Pueblo and then through Salida, Montrose and Grand Junction on its way to the Utah state line.

All of this designation and consolidation of transcontinental routes had little effect on bridge construction in Colorado other than to prioritize the work on the more heavily trafficked routes. Several concrete structures remain from this formative period in Colorado highway history, the most noteworthy of which include the Road Canyon Bridge [5LA8163] in Las Animas County and the Butte Valley Bridge [5HF1907] in Huerfano County, the two oldest remaining bridges from the North-and-South Highway, built in 1912 and 1916, respectively; and the Harmony Canal Bridges [5LO229 and 5LO422] in Logan County and the Cottonwood Creek Bridge [5SW70] in Sedgwick County, the three remaining intact bridges from the Lincoln Highway.

5 Depression-Era Bridge Construction

During the 1930s the Great Depression devastated the nation's economy, leaving millions jobless and homeless. By 1933 more than 13 million workers were unemployed and more than a thousand homes were being foreclosed upon each day. In an effort to alleviate the financial distress, at least in part, President Franklin Roosevelt established a variety of federal agencies whose primary purpose was to funnel billions of dollars of relief money to the destitute citizenry. A favored way of distributing funds to the unemployed was by means of so-called make-work projects—maintaining national forests and parks, producing artwork for public places, writing tourist guides, documenting historic sites, constructing buildings, irrigation works, dams, roads and bridges, etc. While devastating much of the United States, the Great Depression proved to be a boon to the nation's road system. One of the first relief agencies established by the Roosevelt Administration was the National Recovery Administration. Started in 1933 (and found to be unconstitutional by the Supreme Court in 1935), the NRA allocated funds for specific projects that were designed solely to put men to work at predetermined wage rates. According to Wiley:

> Originally the limit was 24 hours a week at a minimum of 30 cents per hour. Later it was raised to 50 cents an hour. Income from gas tax dropped in 1932 to $3.7 million, and federal aid was way down to $2.1 million. Using hundreds of men at manual labor all over the state naturally reduced the value of work completed, and the total that year was only $4.2 million.[107]

In 1932 Congress also passed the Federal Emergency Relief and Construction Act. Under this Colorado received a grant of $3.5 million in 1934. Designated for road and bridge construction, the legislation stipulated that not more than half of the millions of dollars allotted under this program was to be used on the federal aid highway system and not less than 25 percent could be directed to extensions of the federal aid system into and through municipalities. While the act initially required states to match funds, that provision was later rescinded, setting a precedent for full federal subsidies. The act also reversed previous restrictions on the use of appropriations for urban highway construction. Not only did the cities need the improvements, but most of the unemployed were concentrated in urban areas. Subsequent legislation encouraged construction of urban grade separations, bridge widenings, and the development of a feeder road network.[108]

Because employment was as important a goal as construction, federal funds came with some unusual requirements, in effect turning the clock back to the days before many labor-saving machines were available. "Cement and reinforcing steel shall be unloaded by hand labor methods," one specification read. "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." Civil Works Administration projects permitted not more than 10 percent of funds be used for equipment or materials, so the state was forced to supply these on most projects. By the mid-1930s the Federal Emergency Relief Administration had corrected this overzealous rule and allowed greater expenditure for materials.

During this time the regular federal aid grants continued from the Bureau of Public Roads. Colorado received $2.3 million in federal aid in 1934 and again in 1935. This was apportioned in the usual way to federal aid projects devoted to road and bridge construction, using the competitive bidding process among private contractors. Bridges were designed, as they had been in the 1920s, by the Highway Department, typically using standard plans. In 1935 the scope of work increased substantially when the state approved a $25 million bond issue, to take effect the following year. In 1936 Colorado spent almost $12.5 million for road and bridge construction, $18.8 million the year after and $13.7 million in 1938. This massive influx of money helped many in the state who were living on the verge of insolvency.[109]

Like the bridges built by CHD in the 1920s, the structures from the 1930s typically featured standard designs. The most noteworthy of these are today distinguished either by their high degree of physical integrity or by their deviance from standard-plan design. Some examples from the first group include the Gunnison River Bridge [5DT1229], a three-span Camelback pony truss in Delta County; the Dotsero Bridge [5EA1604], a long-span Parker truss in Eagle County; the Spring Creek Bridge [5FN1652] and the Rocky Ford Highline Canal Bridge [5PE3985], two concrete-filled spandrel arches in Fremont and Pueblo counties; the Rocky Ford Bridge [5OT758], a multiple-span steel stringer bridge over the Arkansas River in Otero County; and the Platte Avenue Subway [5EP3673], a group of three small-scale spans that make up an urban grade separation in Colorado Springs. Those from the second group include the Beaver Creek Bridge [5WN51], a multiple-span steel plate girder structure in Washington County; two railroad underpasses [5AM1373 and 5AM1374] in Commerce City; the Arkansas River Bridge [5CF416] and the Sevenmile Bridge [5ML27], steel deck trusses in Chaffee and Mineral counties; and the Colorado River Bridge [5GA2324], a long-span steel girder bridge in Grand County.

In addition to programs administered through the state highway departments, the federal government undertook road construction projects through one of its own agencies, the Works Progress Administration (later renamed the Work Projects Administration). Created by executive order in 1935, this agency was responsible for numerous small-scale projects around the country. About 75 percent of these projects involved construction of some sort. The majority were planned, initiated and sponsored by cities, counties or other public agencies, with local match of funds that ranged from 10 to 30 percent. One of the favored venues of WPA work was road and bridge construction. "WPA is doing its share to cut down the tragic toll of sudden death on America's highway," *The WPA Worker* reported in July 1936. "Under the Emergency Program, workers from relief rolls have replaced thousands of narrow and dangerous bridges. They have built 11,000 new bridges in addition to repairing 17,000 others."[110]

In Colorado the WPA employed as many as 43,000 workers at one time on projects that ranged from sewing and writing to landscaping urban parks, constructing libraries and hospitals and grading roads. According to *The WPA Worker*, "The vast panorama of roads and bridges, of new school houses and additions, or sidewalks and curbs, of unsightly trash holes covered and landscaped into scenic spots, of new camping nooks in the mountains, of flood protection in retaining walls and rip-rapping, altogether have set this state ahead by many decades."[111] By March 1936 the WPA had undertaken 158 road and bridge construction projects in Colorado aggregating $5.3 million in costs. State WPA director Ralph J. O'Rourke explained the purpose and operation of the WPA:

> It should be understood that the primary responsibility of W.P.A. projects is the employment of able bodied but destitute workers. With this responsibility in mind W.P.A. is exerting every effort to conduct projects along

> economical and efficient lines. Wherever possible W.P.A. has developed the type of work which will react to the benefit of the community in which the work is being performed, and it is believed that a large part of the funds expended on these projects will be returned to the community through improved conditions, elimination of dangerous roads, and the stabilization of existing highways by improved drainage facilities. Experienced personnel has been assigned to inspect the conduct and progress of the work. It is the responsibility of the sponsor of a project to provide plans and specifications for work which is to be conducted under the W.P.A.; however, W.P.A. field engineers are instructed to confer with the sponsors about changes when sound engineering principals have not been followed in the preparation of plans.[112]

In September 1935 the WPA budgeted $1 million to reconstruct scores of bridges in southeastern Colorado that had been damaged or destroyed by floods on May 30 and June 1. With little time before the roads were needed for harvest season, the WPA adopted CHD standards for the bridges' construction. WPA crews in Prowers, Las Animas, Bent and Baca counties rebuilt some 300 structures that fall. Only three of these bridges employed steel superstructures; the remainder were relatively small-scale structures built of timber and stone. In August 1936 the WPA completed its longest bridge in the state, a 74-span structure over Bijou Creek in Morgan County, as well as major timber trestles over the Arikaree River in Yuma and Washington counties. The WPA continued to build roads and bridges in southern Colorado through the late 1930s, although no subsequent years could compare with 1936 in terms of productivity. During this period WPA stonemasons constructed such noteworthy structures as the two arch bridges over North Butte Creek [5PW130 and 5PW133] in Prowers County; the Burro Cañon Bridge [5LA1825] and the Zaracillo Canyon Bridge [5LA8103] in Las Animas County; the Rito Seco Creek Culvert [5CT322] in Conejos County; the Little Fountain Creek Bridges [5EP530.69 and 5EP530.70] in El Paso County; and what was perhaps the WPA's best work in Colorado, the Douglas Crossing Bridge [5PW44] over Two Butte Creek in Prowers County.

The WPA program wound down as the United States entered World War II, ceasing operations altogether in 1943. Between 1935 and 1943, it had employed some 8½ million people (with over 30 million dependents), who performed nearly 19 billion hours of work for $9 billion in subsistence wages. The resulting public works projects completed by the WPA changed the physical fabric of America, if for no other reason than their sheer numbers. In its nine years of service the WPA was responsible for construction or repair of 650,000 million miles of roads and tens of thousands of bridges; construction of 40,000 new public buildings and improvement to 85,000 others; construction of thousands of public parks, playgrounds, swimming pools and tennis courts; construction or improvement of thousands of municipal airports; construction of sanitation and water works, flood control systems and irrigation systems; and preservation of numerous historic buildings, including Independence Hall in Philadelphia and Faneuil Hall in Boston. By all accounts the program was successful. Work for the unemployed, WPA Director Harry L. Hopkins stated, "preserves a man's morale. It saves his skill. It gives him a chance to do something socially useful."[113]

6 Interstate Highways

By the 1940s Colorado had been crossed by all manners of transcontinental highways running east-west, but the first true limited-access interstate route—the Valley Highway through Denver—extended north-south. The Valley Highway was built between 1948 and 1958, but planning for the new freeway had begun decades earlier. The volume of automobile traffic had concerned city planners almost from the time that there were autos on Denver's streets. During the 1920s and 1930s Santa Fe Drive was the main entrance to the city from Colorado Springs. This was reinforced in 1928 by the completion of the last concrete paving on the Denver-Colorado Springs Highway (U.S. 85), which entered the city on South Santa Fe. From Santa Fe north, however, traffic often slowed to a crawl. The same thing occurred along Federal Boulevard and Washington Street, the city's main access from the north.

To help alleviate the congestion, Denver tried to organize a highway in 1938 that followed the South Platte River corridor north from Santa Fe. Called the Platte Valley Drive Road, the proposed route was designed in anticipation of a Public Works Administration grant. But the local organization fell through, and the highway never got off of the drawing board. Parts of the four-lane road were later built by the WPA in 1939-1940. One section extended from south Denver to about the Colfax Avenue Viaduct; a second section was built from Denargo Market to 38th Avenue. The center section through the industrial area and the railroad yards was left to the future. This four-lane street would be the precursor to the Valley Highway.[114]

During the late 1930s and early 1940s, the city and the State Highway Department had been seriously contemplating the traffic problem. A major study of Denver traffic occurred in 1942, when the City Club of Denver took a comprehensive look at cars in the city. The resulting report by the City and Regional Planning Committee was titled *Suggestions and Recommendations to Stimulate the Movement and Parking of Vehicles in Denver and Adjacent Areas*. "Denver has experienced in the first third of the twentieth century, along with many other large metropolitan centers, a population growth greater than the national average for rural areas," the report began, "and an increase in vehicular registration even greater than the population growth. Our streets and highways were built for the horse and buggy era and, without much change, are expected to carry the traffic created by this population and vehicular growth." The report offered little in the way of concrete solutions, instead calling for new legislation, new zoning and more studies on traffic patterns.

The study did suggest the designation of major arterials in and around Denver. To speed traffic, the committee proposed developing two belt line systems of streets—an "Inner Belt Line System," which passed through the central business district, and an "Outer Belt Line System." The inner belt line would run along existing streets: Broadway, Lawrence, Market, Speer and Colfax. The outer belt line—consisting of Colorado Boulevard, Evans Avenue, Federal Boulevard and 46th Avenue—would form a perimeter around the city's center. "Since the function of a belt line is to <u>move</u> traffic," the report stated, "the streets suggested are of comparatively adequate width and as free as possible from mass transportation facilities. Traffic should, therefore, be encouraged to maintain the speed necessary to move the volume of traffic imposed upon such streets."[115]

The intent of the City Club's plan was to define arterial streets that would relieve traffic congestion. But these belt lines would still be city streets, with traffic signals, streetside parking and unregulated access from side streets. Traffic might have been eased to an extent under the plan, but the arterials could hardly be called highways. Clearly, what was needed was a more radical approach to transportation planning. What was needed was a limited-access highway similar to Detroit's Davison Freeway, one of America's first limited-access expressways. Charles D. Vail, the Colorado State Highway Engineer, had just such a thoroughfare in mind when he convinced the state legislature to pass the Freeway Act in 1941. Strengthened two years later, the legislation enabled the Highway Department to declare a section of road or right-of-way to be a freeway with controlled access.[116]

With the legislative wherewithal to build a freeway, Vail could begin large-scale planning for its routing through the city. World War II would prevent actual construction, but Vail was already beginning to think toward the peacetime ahead. In September 1944 he commissioned Denver consulting engineers Herbert S. Crocker and Alfred J. Ryan to study the feasibility of what the Colorado Highway Department termed "the Denver Project"—a north-south limited-access highway through the city. Unlike the City Club's study two years earlier, Crocker and Ryan's report offered an exceedingly specific plan for a Denver freeway. Titled *The Valley Highway: A North-South Limited-Access Highway through Denver*, the report marked the first use of the name "Valley Highway." Crocker and Ryan began with a brief history of the Denver Project:

> For a number of years studies to improve the highways approaching Denver have been carried on by both the Colorado Highway Department and the Public Roads Administration. One result was the construction of extensive stretches of four-lane road, but the need for more radical improvement in the near future was recognized. Within the past two years the studies were accelerated by the necessity of developing definite plans for post-war resumption of highway improvement suspended at the outbreak of hostilities.
>
> At the time the present work was initiated it had been concluded, with the approval of Governor Vivian, that this north-south route should be given a primary place in the state's post-war highway plans, because of its urgency as a means of relieving the existing pressure of traffic as well as because of its interregional function. Surveys determined that the improvement should be a limited-access highway located on a new alignment approaching Denver on the north along a line lying between the present U.S. Highway 87 and State 185, and on the south along the valley of Cherry Creek. This determination rendered it imperative that an efficient means of passing through the city be developed.[117]

Unsurprisingly, the consultants concluded that a limited-access highway was vital to Denver's future. In the report they stated the strongest rationale to date for the highway:

> A transportation facility adequate for present and coming requirements obviously should be freed of the throttling effect of Denver's street traffic. This is not to be accomplished merely by widening an existing street or laying out a new street; instead, a traffic-way must be opened which will be independent of the cross-flow of city traffic and will serve as an artery of unimpeded transport while at the same time providing fully for distribution and reception of traffic destined to or from Denver.
>
> It is clear, also, that a vital facility of this kind must be planned for enduring service. Its function is to carry not merely the traffic of today or of the next few years but that of the future, so far as it can be foreseen.[118]

Crocker and Ryan studied four alternative routes: Colorado Boulevard, Broadway, Federal and the Valley route. The Valley Route would follow the Platte River Drive from about 52nd Avenue at the city's northern edge, along a broad bend of the South Platte River to Alameda Avenue. South of Alameda, the proposed valley route would swing along a southeasterly line to University Boulevard.[119] It was, they concluded, the best of the four alternatives. They concluded:

> We find that a valley location is outstandingly superior. All others either are more costly by reason of existing occupancy and property uses, or they do not afford equally efficient traffic service, or they involve an extent of

> disruption of city business and established city districts that renders them unacceptable at the present time. . . . The valley route proves on detailed study to satisfy all the criteria of desirable route selection. The service as well as the cost factors are strongly in its favor. It is markedly superior to alternative routes in respect to distribution, as its central location gives most direct access to the objective points of traffic and facilitates interchange with transverse thoroughfares. Its physical conditions result in low right-of-way cost and economical construction, and its directness assures low operating cost.[120]

With its cost projected at $14.5 million, including acquisition of right-of-way, the Valley route was also the least expensive of the four alternatives.[121]

In their report, the consultants described the valley route in great detail. It would be unlike any other highway built to date in Colorado. The report explained:

> The Valley Highway . . . is designed to be a dual highway segregated from adjoining property, accessible only at special access or interchange points, and with opposing and conflicting traffic fully separated. Its two 2-lane roadways, which are in effect distinct highways independent as to alignment and grade, are divided by a median strip 44 feet wide, unbroken by connecting passages. Wide right of way, enclosed by fencing, protects the highway from lateral trespass, and planting in the median and side strips serves to screen the two roadways from each other and from outside property, minimizing glare interference and noise transmission. The wide median strip allows space for adding a third lane in each direction when required; it is to be built on the inner side of the initial roadways, leaving an ultimate median strip 20 feet wide. Full lighting of the highway is planned, in the interests of traffic safety and free flow.[122]

The highway would be built with four lanes over most of its length, but it was designed to accommodate six lanes by subsequent widening. Each lane was 12 feet wide and paved with concrete with an asphalt overlay. A three-foot-wide curb strip would adjoin the inner edge of pavement, and a five-foot-wide lip gutter would bound the outer edge. Beyond this gutter would be additional paving to provide a shoulder for disabled vehicles. Interchange configurations were based upon the volume of traffic that they would carry and the geometry of the city street crossing. Cloverleafs were used at the major intersections; simple ramp connections would suffice for minor interchanges. The Downing Street interchange featured the only rotary interchange in Crocker and Ryan's plan.[123]

The engineers had envisioned portions of the Valley Highway as a boulevard of sorts, featuring aesthetically proportioned overpass structures integrated in a park-like setting with planted landscaping: like a high-speed version of the divided parkways of Kansas City. “Landscaping is planned as an integral element of the highway construction,” they stated. A ten-foot-wide strip along the roadway in the median would be planted with grass, and the area between these grassy strips would be planted with shrubs and low trees to function as a barrier against headlight glare and noise from opposing lanes. In residential areas, taller trees and shrubs would be planted along the right-of-way edges to buffer the surrounding neighborhoods from the din and glare of the freeway. Additional planting at grade separations would help to integrate the structures with the surrounding landscaping. To sustain all of this planting, a sprinkling system would be installed. To illuminate the highway, light standards would be spaced at 225-foot intervals along its length.[124]

Crocker and Ryan delivered their report to Charles Vail in December 1944. Vail died a month later without having acted on it. Over the next four years, the Valley Highway proposal would languish in bureaucratic limbo, as commissions, agencies and citizens' groups took aim at the Denver Plan. The first broadside came in March 1945, when the Highway Advisory Board instructed Vail's successor, Acting State Highway Engineer A.F. Hewitt, to terminate Crocker and Ryan's contract. The unsettled state of post-war finances made construction of the freeway unlikely, they reasoned, and in May Hewitt complied with their directive. Early the next year Mark U. Watrous succeeded Hewitt and, after waging a court battle opposing his appointment, convinced the Advisory board to reactivate the engineers' contract. Crocker and Ryan began working on detailed construction drawings that summer.[125]

One year later, in August 1948, the State Highway Department finally let the first construction contract for work on the Valley Highway. Awarded to Colorado Constructors, Inc., for $284,000, this project entailed reconstruction of a large-capacity sewer line and irrigation ditch at the point where the freeway would cross West 48th Avenue. A second, smaller contract was granted to build a drain under the Colorado & Southern Railroad nearby. In October CHD awarded the first major contract for construction of the highway itself to the Northwestern Engineering Company of Denver. At $2.2 million it was the largest single highway project then undertaken by the Department. Northwestern would build the northernmost section of the highway, beginning at West 52nd Avenue and extending 2¼ miles southward to West 36th Avenue. Ground was broken ceremoniously on November 16, 1948, marking the beginning of an immense construction campaign that would take ten years and some $33 million to complete.[126]

Under a tripartite agreement, the City of Denver would pay for acquisition of the right of way for the highway and feeder streets, and the Colorado Department of Highways and the U.S. Bureau of Roads would provide equal funding for highway construction. In 1947 and 1948 the city had spent $1 million purchasing properties in the highway's path, with another $6 million anticipated. By the time the first construction contracts were let in 1948, however, the city had already exhausted its land acquisition fund. The agreement was later modified to allow the Highway Department to purchase the land, with the city reimbursing the state as funds became available.[127]

Through 1949 construction of the freeway proceeded steadily southward. “The Northwestern Construction Co. has been speeding erection of steel-and-concrete masses which are the first projects of a cross-town road system that will provide safe, fast transportation through Denver,” reported the *Rocky Mountain News*. By the time the contractors quit for the winter in mid-December, they had partially completed the two northernmost interchanges at West 48th Avenue and West 38th Avenue. “They left, too, an intricate pattern of sweeping designs and elevations that will smooth into sleek super-highways and fast loops that link into crosstown traffic lanes.” The contractors had substantially completed overpasses over West 44th Avenue and the tracks of the Colorado & Southern Railroad and had graded much of the highway between West 52nd Avenue and the railroad.[128]

While the contractors waited for the weather to improve early in 1950, city, state and federal officials were negotiating changes in the right-of-way acquisition process. It had become apparent that Denver could not afford the projected $7 million price tag to acquire some 500 separate properties. Moreover, the city's slow-paced acquisition would impede the construction process. In a compact made that February, the state agreed to purchase a portion of the property, assisted by federal funding. This arrangement would speed the acquisition process and allow the city to spread its expenses over a longer period of time, and, most importantly, it would reduce the city's bill for the highway by about $3 million. Like the construction, land acquisition was subdivided into sections. Procurement of the first section, involving the northernmost section of highway, had already been completed, with subsequent sections due to be cleared later in 1950 and 1951.[129]

Large-scale construction recommenced in April 1950 but was halted a few weeks later by a general strike of the Denver building trades union. That summer the work again resumed in earnest, and by November the first short section of highway was opened to traffic. Navigating the new type of thoroughfare proved a novel experience for Denver drivers. Motorists unaccustomed to freeway driving struggled at first with the dizzying speed and serpentine interchanges. "There were reports citizens had been lost for hours in that maze of asphalt and concrete," the *News* reported with tongue in cheek. "There was talk that some DU psychiatrists were using the highway as a gigantic laboratory maze to see how much people can take before they go crazy." The Rocky Mountain Auto Club attributed the greatest hazard of freeway driving to "the heavy footed driver who refuses to let up slightly on his accelerator so that a car can enter from a ramp." To assist freeway novices, the AAA published a "Guide to the Valley Highway," giving tips for high-speed driving. The guide explained:

> The danger caused by motorists who "do not know how to drive on freeways or who are totally indifferent to the rights of others on the highway."
>
> What to do when encountering signs reading "Yield" and "Merging Traffic."
>
> That there is a difference between an "Upcoming Exit" sign and a "Must Exit" sign, which many people are having trouble understanding.
>
> That the word "cloverleaf" denotes a spaghetti-like intersection of the Valley Highway with another major roadway. Cloverleafs are so named because they look like a cloverleaf from above, and they are good ideas because they enable two major roadways to intersect without the usual stoplights.
>
> That it generally is not necessary to stop when entering a limited-access freeway in the manner that one stops when entering a regular sort of street.
>
> That slow drivers on a freeway are as dangerous as fast drivers.[130]

Every interchange and all intersections where city streets or railroads carried across the freeway required overpasses and underpasses to be built to separate the traffic flow. Additionally, the freeway crossed the South Platte River near Wazee Street, necessitating construction of a major span to carry the highway. As a result, a total of 62 structures were built over the highway's 11-mile length. For the Platte River crossing and the lengthy elevated viaduct at Broadway, Crocker and Ryan delineated riveted steel girder superstructures. For the smaller grade separations, they specified reinforced concrete. "Development of general designs for the structures of the Valley Highway has been worked out with regard to both economy and satisfactory appearance, in addition to the primary requisites of strength and permanence," they stated in their 1944 master plan. "All interchange structures are planned to be of rigid-frame construction of concrete, while the river bridge and the bridges carrying the main-line railroad tracks over the Highway have been designed as steel plate-girder structures on concrete substructures. All have been designed for a loading corresponding to most advanced modern traffic conditions." [131]

The overpasses that Crocker and Ryan had designed for the Valley Highway were typically comprised of paired identical structures. In this they employed an architectural formality that was as much aesthetic as practical. "The bridges which carry the Valley Highway over streets or railway tracks are planned to be dual, consisting of two parallel bridges each carrying a one-direction roadway, including any speed-change lanes that reach or traverse the bridge. The space between the parallel bridges would be left open. Underpass bridges are single structures." Crocker and Ryan's master plan illustrated their pared-back aesthetic for the overpasses and underpasses. "A plain form of design has been adopted," they stated, "devoid of special architectural organization or ornament, in the belief that the simplicity of such construction and its direct expression of function will have full esthetic value." In this they were hewing to the emerging modernist aesthetic that held structural expression as a virtue and applied ornamentation as a vestigial remnant of past design. Still, the engineers had hedged their bets in 1944, stating, "In the course of detail design fuller consideration will undoubtedly be given to the esthetic possibilities and requirements of these structures." [132]

True to their original design, the structures built along the highway in the 1940s and 1950s were left unornamented. The only architectural expression in the concrete construction took the form of battered bulkheads at the abutments. Guardrails on the overpasses and underpasses were similarly kept simple, featuring modestly decorative steel post-and-beam configurations. This simple design, while coordinated with the clean profile of the structures, would also facilitate maintenance. "In view of the snow conditions likely to prevail in the Denver region in winter, open railings are believed to be necessary to prevent accumulation of snow in storms. For this purpose as well as the interests of economy and simplicity, a simple open metal railing is suggested."

Like many state highway departments, CHD had used rigid-frame bridges sparingly during the 1930s and 1940s, reserving their use for limited applications. The Valley Highway, with its numerous rigid-frame overpasses, represented a significant change in philosophy for the agency and marked the first concerted use of rigid-frame highway construction in Colorado.

Work on the highway continued in relatively small pieces southward from the original section through 1950 and 1951. When problems with right-of-way acquisition threatened to stall progress late in 1950, the Department hired contractor Peter Seerie to begin work on the twin steel arches over the Platte [5DV7051], further south. Completed by the following August, the Platte River bridges stood isolated for months until the highway eventually reached their location. By then work had been undertaken to varying degrees in three of the first five sections between West 52nd Street and West 10th Avenue.[133]

Additional problems with funding and right-of-way procurement in 1951 prompted the Highway Department to reconsider its contiguous north-to-south strategy. Rather than continue southward through the Platte Valley commercial/industrial district, where property values were relatively high, the agency opted instead to skip to the Colorado Boulevard interchange near the highway's south end, where most of the land was already in the city's possession. As the southernmost cloverleaf on the Valley Highway, the Colorado Boulevard interchange was pivotal to the highway's connection with the proposed upgrading of the Colorado Springs Highway into a limited-access freeway. According to Watrous, the Highway Department would complete the freeway as far south as the Sixth Avenue interchange in 1952 before shifting operations south to Colorado Boulevard. "Purchase of rights-of-way from South Colorado Boulevard to South Downing Street—roughly along the present site of Buchtel Boulevard—will cost comparatively little," he stated, "but those expenses are expected to zoom when the project enters industrial and business districts."[134]

The Highway Department was by this time staggering construction on the freeway's component parts. Contracts for bridge construction were let in advance of adjacent road grading so that both could be completed at about the same time. Consulting engineer Clifford Price was engineering the structures in the southern section, using the concrete rigid-frame design developed by Crocker and Ryan. Using this method, the underpasses and overpasses between Colorado Boulevard and Logan Street were designed and built.

Early in 1953 the Highway Department began work on the first of these structures by contracting with the Lawrence Construction Company to construct a twin-span underpass at Steele Street [5DV6033.8], immediately north of Colorado Boulevard. CHD hired James B. Kenney to build similar structures at Franklin [5DV6033.6] and South Downing [5DV6033.5] streets. The latter crossing had by then been downsized from its original rotary configuration to a simple ramped interchange. By August the Steele Street underpass was complete and the Downing and Franklin structures were underway. The contract for the Colorado Boulevard interchange [5DV7089]had been awarded to the Lowdermilk Brothers for about $550,000, and Lawrence had been hired to build the University Boulevard interchange [5DV6033.7]. Grade separations at both of the interchanges were completed in 1954.[135]

The freeway was about half finished by then, and several sections had been opened to traffic. In June 1954, with the underpass at Colorado and the overpass at University completed, the Highway Department looked forward to continuing work northward at the deliberate pace it had used for the previous four years. The *Post* reported: "The Valley Highway work will involve construction of the road from the interchange on S. Colorado Blvd. to S. Emerson St. A total of $1,300,000 is contained in the new budget for this project." But land acquisition again threatened to slow the construction pace. "Unless the state takes over right-of-way buying for the rest of the cross-town freeway, Valley Highway construction will grind to a halt in about 18 months," city official Thomas Campbell told the State Highway Commission in December. "Unless Denver receives additional [financial] relief, there is grave danger that the very purpose for which the Valley Highway was intended—the movement of traffic in and through the capital city—will be greatly diminished."[136]

Construction did almost grind to a halt in 1955, with completion of the 2¼-mile stretch through the residential area between Colorado and Emerson representing the only real progress on the highway. Costing about $2.5 million, this section was opened to traffic in November, but parts still remained unfinished. The Colorado Boulevard interchange was then operational, and the grade separation at University carried traffic under the highway, although the surrounding cloverleaf here had yet to be completed. The underpasses at Steele, Downing and Franklin had been completed, with other underpasses remaining to be built at Emerson, Louisiana, Logan and Washington.[137]

Revival of large-scale construction on the Valley Highway came from the federal government in 1956. That June Congress passed the Federal Highway Act, which injected huge amounts of federal monies into the newly established interstate highway system. Acting on President Eisenhower's recommendation, Congress authorized $33.5 billion for construction of over 41,000 miles of superhighways throughout the country over the next sixteen years. This represented by far the most ambitious public works program ever undertaken by the U.S. For Denver, the new program was a boon: the Valley Highway became immediately eligible for extensive federal funding.

In June 1956 the Highway Department contracted with C.L. Hubner and Company to build an underpass at Evans Avenue [5DV6033.10], the highway's southern terminus, and a three-span plate girder structure to carry the Colorado & Southern Railroad [5DV6033.9] over the highway. The new project, which commenced that month, was only one of several sections of the highway then underway. Elsewhere, contractors were busy building the Speer Boulevard interchange [5DV7052 and 5DV7054], a pair of bridges over the railroad tracks at West Myrtle Place, and other bridges at West 13th and West 6th avenues. The highway was then complete on the northern end from West 52nd Avenue to 16th Street and on the southern end from Colorado Boulevard to Downing. Massive twin viaducts at Broadway were on Johnson's drawing board.[138]

In late 1956 and early 1957, flush with the promise of new federal funds, CHD granted contracts worth $3.5 million for construction of the Alameda Avenue interchange [5DV7074], the Broadway Viaducts [5DV7070 and 5DV7071], a railroad overpass near 6th Avenue, and an underpass at Logan Street [5DV6033.1]. This constituted the largest group of contracts awarded for Valley Highway construction and formed a distinct contrast with previous years' contracts, which had dwindled markedly. More projects were initiated that summer, and by January 1958 contractors were pushing the work on eight separate sections worth $8.4 million. This included concrete underpasses at Washington Street [5DV6033.2], Louisiana Avenue [5DV6033.2], and Emerson Street [5DV6033.3]. A month later the Highway Department let the contract for the final two miles of grading and paving between West 3rd Avenue and Emerson. In a fitting act of symmetry, the project was granted to Colorado Constructors, Inc., the firm that had won the first highway contract ten years earlier.[139]

Construction was hurried through 1958 in an effort to complete the highway by the end of the year—the symbolic tenth anniversary of its start. In October the *News* could report that the freeway was near completion. "Denver's Valley Highway, the biggest single road project in state history, will be completed in about four weeks," the newspaper stated. The Highway Department staged a formal ribbon-cutting opening on November 23, 1958, almost ten years to the day after the opening ceremony staged in 1948. Lt. Governor Frank Hays and Colorado Supreme Court Justice Albert Frantz cut a ribbon on the northbound lane of the Broadway Viaduct, while Acting Mayor Richard Batterton and City Councilman George Cavender simultaneously cut another on the southbound lane. Barricades were removed, and the highway was opened over its entire length. Denver Mayor Nicholson suggested renaming the highway the Falcon Freeway, saying, "The Valley Highway, in itself, really does not connote anything outstanding. As a matter of fact, the highway does not run in a valley, it runs through the city and beyond the city limits on the plains." Fortunately, no one took Nicholson's suggestion seriously; the Valley Highway moniker stuck.[140]

With the new freeway complete, the Highway Department could take stock of its constituent parts. The 11.2-mile highway contained thirteen major interchanges, four minor ones and a total of 62 bridges and grade separations. These structures, along with gutter and pavement inlets, consumed 130,000 cubic yards of concrete and hundreds of thousands of tons of structural and reinforcing steel. Embankment construction involved moving some five million cubic yards of earth. Conduits for lighting wiring extended about 100 miles. Highway construction involved placing more than 73 miles of pipe ranging in size from 1½ to 78 inches in diameter. The largest grade separation—and the most expensive highway structures built to date in the state— were the twin steel viaducts at Broadway. Costing $2.3 million, the Broadway Viaducts [5DV7070 and 5DV7071] extended 1,733 feet and required 10,693 cubic yards of concrete, 1.3 million pounds of reinforcing steel and 3.6 million pounds of structural steel.[141]

As conceived by the Highway Department and as built, the Valley Highway would join with the re-configured Colorado Springs Highway on its southern end. By the time that the Valley Highway through Denver was ceremoniously opened to traffic in November 1958, CHD had already begun construction to upgrade the Colorado Springs Highway into a limited-access freeway and link it with the Valley Highway. The new interstate would extend southeast from Evans Avenue, past Hampden Avenue and Arapahoe Road on its way to the Arapahoe County line. From there it swung southward through Castle Rock to Colorado Springs.

In Colorado Springs, as it had in Denver, the Highway Department had been working to upgrade the central route through the city since the 1940s. In 1944 CHD District Engineer James D. Bell began plotting the highway's path through Colorado Springs. The city commissioned a study of its own, which was incorporated into a report that CHD Urban Planner Dan Ormsbee produced in 1947. Ormsbee's report outlined three possible routes for the proposed highway: the Union Avenue Line at the extreme eastern edge of the city; the Shooks Run Line, which followed the Santa Fe Railroad through the eastern part of the city; and the Walnut Street Line, which cut through the center of the city. "The selected route must serve the best interest of the traveling public," Ormsbee stated, "as related to through traffic, local traffic and vehicular movement within the city." The Highway Advisory Board eventually agreed that the Walnut Street route was the most suitable, but limited funding delayed construction for another seven years. Early in 1954 CHD completed construction drawings for the roadway and structures along its route. The new highway, like the Valley Highway in Denver, would be built to conform with new interstate highway standards, with four uninterrupted lanes with cloverleaf entrances and exits.[142]

The Highway Department let the initial construction contract for the Monument Valley Freeway in November 1955. Costing $1.9 million, it entailed grading of 12.7 miles of highway from the south end of Nevada Avenue south to Fountain. A month later CHD awarded the second contract, costing $510,000, for construction of major structures. According to CHD:

> The first contract for work on the freeway proper, between Nevada Avenue and Cimarron Street, was awarded on November 1, 1957, and represented an investment of $2,250,000. Ten additional projects were let, including the one now under construction which extends the Freeway northward to the Woodman Road Interchange . . . . As quickly as a section of the Freeway was completed, it was opened to traffic to permit use of the facility by the public as soon as possible. The thought, ingenuity, labor and vision of many men have gone into the construction of the Monument Valley Freeway, together with the power of hundreds of machines and the strength of thousands of tons of gravel, asphalt, concrete and steel.[143]

The Monument Valley Freeway was opened ceremoniously on July 1, 1960. Taking five years to build and costing $12.2 million, it extended 11.9 miles through the center of the city to connect with the North-South Highway on both ends. The new freeway contained 22.6 miles of two-lane roadway, 10.4 miles of ramps and 6.5 miles of frontage roads. It required excavation of 4.9 million cubic yards of earth and placement of 29,520 cubic yards of structural concrete, 223 million pounds of asphalt and almost 20 miles of buried pipe and conduit. When finished, the new route contained 38 bridges and grade separations.

A similar scenario played out in Pueblo during this same time. In 1949 Ira K. Young, a Pueblo resident and member of the Colorado Highway Advisory Board, began lobbying for construction of a major highway through Pueblo to ease the congestion of motor traffic on U.S. 85 through the city. Patterned after the proposed limited-access highways in Denver and Colorado Springs, the route that Young had envisioned was one that had been surveyed in January 1941 by CHD Resident Engineer Ralph Tillson. As a precursor to Young's freeway, the Highway Department in 1949 undertook construction of 3¼ miles of the route above 40th Street and a grade separation between U.S. 85 and U.S. 50. It would not be until seven years later, when Congress enacted the Federal Highway Act of 1956, however, that the Department began large-scale planning for a limited-access highway that would extend through the heart of the city. CHD first re-surveyed the proposed route. "When a definite line was decided upon, east of the CF&I plant and largely through a blighted area," the Highway Department later reported, "most of the appropriations were utilized for the acquisition of right of way." With the route designated and property acquired, the Department could begin actual construction. For logistical purposes, CHD divided the work into 20 separate contracts, opening sections of the interstate to traffic along the way as they were completed.[144]

In the summer of 1959 the Pueblo Freeway was finished. Extending 9.2 miles and costing $10.6 million, the new highway involved some 1.8 million cubic yards of excavation work, and it consumed 19,000 cubic yards of concrete, 80,000 tons of asphalt, 25.5 miles of pipe and 19 miles of electrical conduit. Included in this construction were 35 bridges and grade separations, ranging in size from small-scale culverts to two multiple-span steel railroad viaducts, 944 feet and 1069 feet long.

Elsewhere in the state the Highway Department was planning or building other legs of the new interstate highways through the mountains and across the plains. Interstate Highway 70 west of Denver began to take shape in 1959 when the Highway Department engaged the E. Lionel Pavlo Engineering Company of New York to reconnoiter the best route for a freeway through the mountains. Pavlo's report, issued in April 1960, covered the 100-mile route between Dotsero and Empire Junction, focusing on a shorter route between Wolcott and Empire that would involve construction of a major tunnel beneath the continental divide. Pavlo recommended that the proposed route follow the existing U.S. 6 corridor from Dotsero up the Eagle River Valley to a point about 14 miles east of Wolcott. Beyond this point it would extend eastward over Vail Pass, through Frisco and Silverthorne to the proposed tunnel and down the other side to Empire.

Construction on Interstate 70 through the mountains followed in the 1960s, culminating with the completion of the first bore of the Eisenhower Tunnel in 1973.[145] Interstate Highway 25 between Denver and the Wyoming state line was completed in October 1964 at about the same time that the highway between Pueblo and Colorado Springs opened; I-25 between Trinidad and the New Mexico was opened in 1967. The last leg of I-25— between Walsenburg and Trinidad—opened two years later. In 1979 the Highway Department finished Interstate 70 between Denver and the Kansas state line, the second bore of the Eisenhower Tunnel and the Vail Pass section of I-70. The last section of interstate highway completed in Colorado was the torturous section of I-70 through Glenwood Canyon, which was finally opened to traffic in 1992 after years of rancorous debate over its design.[146]

[1]David Plowden, *Bridges: The Spans of North America* (New York: The Viking Press, 1974), 34.

[2]J.A.L. Waddell, *Bridge Engineering* (New York: John Wiley and Sons, Inc., 1916), 35.

[3]Plowden, 61.

[4]Wrought Iron Bridge Company, *Book of Designs of Wrought Iron Bridges Built by the Wrought Iron Bridge Company of Canton, Ohio* (Canton: Hartzell & Saxton, 1874), 9.

[5]Waddell, *Bridge Engineering*, 23-27; Donald C. Jackson, *Great American Bridges and Dams* (Washington, D.C.: Preservation Press, 1988), 28-29.

[6] "A Note on Early American Suspension Bridges," *Engineering News*, 16 March 1905, 269.

[7]Caleb Hornbostel, *Construction Materials: Types, Uses and Applications* (New York: John Wiley and Sons, 1978), 205; Pedro Guedes, *Encyclopedia of Architectural Technology* (New York: McGraw-Hill Book Company, 1979), 253-255.

[8]Plowden, *Bridges,* 297.

[9]Ibid.; "The Present Status of Reinforced Concrete Bridges," *Engineering Record* (13 August 1910): 169-170; Henry S. Jacoby, "Recent Progress in American Bridge Construction," *Scientific American Supplement, 19 July 1902, 22199.*

[10] "City Bridges," *Engineering Record*, 3 June 1911.

[11]Plowden, 298.

[12]Thomas H. MacDonald, "Bridge Patent Litigation in Iowa," *The Iowa Engineer* 18:4 (January 1918), n.p.

[13] "J.B. Marsh Is Dead at 60," *Des Moines Tribune*, 26 June 1936.

[14]As quoted in Plowden, *Bridges*, 166.

[15]Secretary of the Interior, *Manufacturers of the United States in 1860, Compiled from the Original Returns of the Eighth Census, Under the Direction of the Secretary of Interior* (Washington, D.C.: Government Printing Office, 1865), 734; *The Statistics of the Wealth and Industry of the United States . . .* (Washington, D.C.: Government Printing Office, 1872), 394; *Compendium of the Tenth Census . . .* Part II (Washington, D.C.: Government Printing Office, 1883), 932; *Abstract of the Eleventh Census: 1890* (Washington, D.C.: Government Printing Office, 1896), 144; *Abstract of the Twelfth Census of the United States*, 3rd ed. (Washington, D.C.: Government Printing Office, 1904), 304.

[16] "Organization of the American Bridge Company," *Electrical World and Engineer* 36:1 (7 July 1900), 38.

[17]Thomas J. Noel, Paul F. Mahoney, and Richard E. Stevens, *Historical Atlas of Colorado* (Norman: University of Oklahoma Press, 1994), 25.

[18]F.L. Bartlett, "The History of Road Building in Colorado," *Colorado Highways* 5:3 (March 1926), 4.

[19]Forest Crossen, *The Switzerland Trail of America* (Boulder: Pruett Press, Inc., 1962), 1-2.

[20]Carl Ubbelohde, Maxine Benson and Duane A. Smith, ed., *A Colorado History* (Boulder: Pruett Publishing Company, 1972), 66.

[21]Noel (1994), 26.

[22]Samuel David Mock, "Railroad Development in the Colorado Region to 1880," Ph.D. dissertation, University of Nebraska, Lincoln, 1938, 21; Wilson, 2.

[23]Dan Hopkins, "Troubled Bridges over Denver's Waters," *Rocky Mountain Motorist*, May 1982, 12.

[24] "Local Items," *Rocky Mountain News*, 18 June 1859.

[25]Jerome Smiley, *History of Denver* (Denver: Denver Times Publishing Company, 1901).

[26]Hopkins, 13.

[27]Smiley, *History of Denver*.

[28]Ibid.

[29] "Denver Has $1,500,000 Invested in Bridge and Viaducts," *Denver Municipal Facts* 1:11 (November 1909), 3.

[30]Smiley, *History of Denver*.

[31]Rodman Paul, *Mining Frontiers of the Far West: 1848-1880* (New York: Holt, Rinehart and Wilson, 1963), 9.

[32]Paul, 125; Frank R. Hollenback, *The Gilpin Tram* (Denver: Sage Books, 1958), 10.

[33]Wilson, 12, 17-23.

[34]Donald B. Robertson, *Encyclopedia of Western Railroad History* Volume 2: The Mountain States (Dallas: Taylor Publishing Company, 1991), 101-109.

[35]Ubbelohde et al., 205-206.

[36]Robert A. LeMassena, *Colorado's Mountain Railroads* (Denver: Sundance Publications, 1984), 311; Josie Moore Crum, *The Rio Grande Southern Railroad* (Durango: San Juan History, 1961), 1-2.

[37]Wilson, 26; Riegel, Robert Edgar, *The Story of the Western Railroads* (Lincoln: University of Nebraska Press, 1926), 6.

[38]Riegel, 21-22. Western railroad financing is an extremely complex topic. Robert Riegel devoted a chapter in his excellent book, *The Story of the Western Railroads*, to railroad finance and the Panic of 1873. George Taylor deals with the subject with a less strictly western focus in his classic *The Transportation Revolution*.

[39]Edward M. McFarland, *The Midland Route: A Colorado Midland Guide and Field Book* (Boulder: Pruett Publishing Company, 1980); Lucius M. Beebe and Charles Clegg, *Hear the Train Blow* (New York: E.P. Dutton & Company, Inc., 1952).

[40]Walter R. Borneman, "Ride the Historic Georgetown Loop: Relive Colorado Mining-Glory Days," *American West* (Issue 3, 1987): 42-44.

[41]Waddell, 21; H.S. Kesner, "Some Recent Missouri River Bridges," *Nebraska Blue Print* 28 (May 1929), 9.

[42]Carl Abbott, Stephen J. Leonard and David McComb, *Colorado: A History of the Centennial State* (Boulder: Colorado Associated University Press, 1982), 5-7. 335-336

[43]Bartlett, "The History of Road Building in Colorado," 5.

[44]Russ Collman and Dell A. McCoy, *The R.G.S. Story*, v.2 (Denver: Sundance Books, 1991), 11-12.

[45]King Iron Bridge and Manufacturing Company, *Iron, Steel and Combination Bridges, Girders and Struc-tural Work* (Cleveland, Ohio: n.p., ca.1888); Wrought Iron Bridge Company, *Illustrated Pamphlet of Wrought Iron Bridges Built by Wrought Iron Bridge Company, Canton, Ohio* (Canton, Ohio: Canton Repository, 1885).

[46]Wilbur Fiske Stone, *History of Colorado* vol. 2 (Chicago: S.J. Clarke Publishing Company, 1918), 651-652.

[47] "Charles G. Sheely, Contractor, Dies," *Denver Post*, 18 December 1934.

[48]Biographical information for the Bullen family is from an oral interview with Joseph A. Bullen, Jr.

[49]The State Engineers were: Eugene K. Stimson (1881-1883); Edwin S. Nettleton (1883-1887); J. Sire Greene (1887-1889); James P. Maxwell (1889-1893); Charles B. Cramer (1893-1895); Horace A. Sumner (1895-1897); John E. Field (1897-1899); Addison J. McCune (1899-1903); Louis G. Carpenter (1903-1905); Thomas W. Jaycox (1905-1909); Charles W. Comstock (1909-1913); John E. Field (1913-1915); and Albert A. Weinland (1915-1917).

[50]The Grand Junction Bridge was replaced in 1933 by the Colorado Highway Department. One of the spans was moved to a remote crossing of the San Miguel River [5MN4984] in Montrose County, where it remains today.

[51]Colorado State Engineer. "Abstract of Projects for Which Internal Improvement Income or Permanent Funds Have Been Appropriated," 1907.

[52]*Sixth Biennial Report of the State Engineer to the Governor of Colorado, 1891-1892* (Denver: Smith-Brooks Printing Company, 1892).

[53]*Tenth Biennial Report of the State Engineer to the Governor of Colorado, 1899-1900* (Denver: Smith-Brooks Printing Company, 1901), 25-26.

[54]*Eleventh Biennial Report of the State Engineer to the Governor of Colorado, 1901-1902* (Denver: Smith-Brooks Printing Company, 1902), 46-47. In so stating, Nettleton made specific recommendations for road improvement:

> More care should be shown in locations where roads are to be permanent. It will pay to hire the services of a competent road engineer in most instances. More care should be shown in the location and construction of the culverts and small bridges, as well as large ones. At least a part of the county funds should be put into permanent work each year . . . In this age of concrete, many small bridges and culverts that are now built of lumber could be built of concrete, or steel and concrete. In most cases for concrete work all the material, except cement, is close at hand, and the difference of cost between the permanent structure and the flimsy one is surprisingly small.

Of course, we can not afford expensive road construction, in the way of macadam roads, neither do we need it in this dry country. What we need is to put our roads on the proper grade; to give them proper protection from wash by storm waters, and in the valley and prairie countries to grade them up, so as to give them drainage and provide necessary culverts. In this country of irrigating ditches many unsightly "humps" are seen in the roads where laterals cross them at a higher grade than the general level of the road. This should be remedied by siphoning the water under the road. Some will say this is not practicable, on account of the filling in of such conduits with weeds, but, we think, with proper construction and proper care, the plan can be worked out successfully.

[55]Marion C. Wiley, *The High Road* (Denver: Colorado Highway Department, 1976), 11; State Highway Commission Proceedings 1 (17 May 1910): 19-24, located at the Colorado Department of Transportation, Denver, Colorado.

[56] "Beginning at the eastern limits of the City and County of Denver, on East Colfax avenue, thence in a general easterly direction to the town of Bennett, thence in a general north easterly direction to, or near the town of Wiggins . . . , thence to the City of Fort Morgan, being designated as State Primary Road No. 7." Proceedings, 1 (17 May 1910): 24.

[57]State Highway Commission Proceedings 1 (24 June - 20 July 1910): 37-40.

[58]State Highway Commission Proceedings 1 (17 May 1910): 19-24.

[59]State Highway Commission, *Second Biennial Report*, *1912* (Denver: Smith-Brooks Printing Company, 1912): 19.

[60]State Highway Commission Proceedings 1 (20 July 1910): 49.

[61]Wiley, The High Road, 11-12.

[62]State Highway Commission, *First Biennial Report, 1910* (Denver: Smith-Brooks Printing Company, 1910), 17-18.

[63]Ibid., 19.

[64]Ibid., 17.

[65]Colorado State Highway Commission, *Second Biennial Report, 1912* (Denver: Smith-Brooks Printing Company, 1912), n.p.

[66]Colorado State Highway Commission, *Third Biennial Report, 1913-1914* (Denver: Smith-Brooks Printing Company, 1915), 1-6.

[67]State Highway Commission, *Bulletin No. 4, Containing General Forms, Specifications, Notes, Plans and Rules* (Denver: Smith-Brooks Printing Company, 1914), 5.

[68]Colorado State Highway Commission, *Third Biennial Report*, 1-6.

[69]F.L. Bartlett, "The History of Road Building in Colorado," *Colorado Highways Bulletin* 1:5 (October 1918), 10. Bartlett's conclusion today seems ironic, given the developmental pressure Colorado's mountains are currently experiencing: "Who can foresee the ultimate results? All that we are sure of is that our mountains are large enough to accommodate [all the visitors] without crowding."

[70]Colorado State Highway Commission, *Fourth Biennial Report* 1915-1916 (Denver: Eames Bros., 1917), 1-7.

[71]Ibid.

[72]George E. Koster, "A Story of Highway Development in Nebraska," typewritten manuscript, 1986, 7.

[73] Wiley, 14.

[74] Wiley, 16-17; L.E. Edwards, "Federal Aid Projects in Eastern Colorado," *Colorado Highways Bulletin* 2:12 (December 1919), 22-23; "State's 117 Federal Projects in Detail," *Colorado Highways Bulletin* 2:11 (November 1919), 8; "Completed Federal Aid Projects," *Colorado Highways* 1:1 (April 1922), 12.

[75] "Rigid Standards Needed in Good Bridge Construction," *Colorado Highways Bulletin* 1:4 (July 1918), 5.

[76] "Standard Bridge Plans," *Colorado Highways Bulletin* 2:11 (November 1919), 12-13, 17; "Standard I-Beam Bridges," *Colorado Highways Bulletin* 2:12 (December 1919), 12-13.

[77] "Associated and United Press Tell World of Pueblo's Flood Prevention," *Pueblo Star-Journal*, 3 June 1926.

[78] Ralph C. Taylor, "Pueblo Completes Bridge Program," *Colorado Highways* 4:4 (April 1925); "Pueblo's Problem of City Rebuilding," *Pueblo Chieftain*, 10 June 1921.

[79] Ralph C. Taylor, "Pueblo Completes Bridge Program."

[80] Wiley, 17-18.

[81] "Editorial Comment," *Colorado Highways* 1:1 (April 1922), 4.

[82] Paul S. Bailey, "Bridge Construction in Colorado Year 1925," Colorado Highways 5:1 (January 1926), 9.

[83] R.S. Du Bois, "Standard Bridge Designs Furnished County Highway Officials Without Cost," *Colorado High-ways,* 2:3 (March 1923), 8.

[84] Paul S. Bailey, "Activities of Bridge Department." *Colorado Highways* 6:1 (January 1927), 6.

[85] Robert M. Ormes, *Railroads and the Rockies* (Denver: Sage Books, 1963), 15.

[86] Wesley S. Griswold, *A Work of Giants: Building the First Transcontinental Railroad* (New York: McGraw-Hill Book Company, 1962), 163; Samuel David Mock, "Railroad Development in the Colorado Region to 1880," (Ph.D. dissertation, University of Nebraska, Lincoln, 1938), 15-16.

[87] Wilson, *The Denver and Rio Grande Project,* 90; Beebe and Clegg, *Hear the Train Blow*, 227.

[88] *Thirteenth Biennial Report of the State Engineer to the Governor of Colorado* 1905-1906 (Denver: Smith-Brooks Printing Company, 1907), 92.

[89] *Tenth Biennial Report of the State Engineer to the Governor of Colorado* 1899-1900 (Denver: Smith-Brooks Printing Company, 1901), 345; *Thirteenth Biennial Report...* 1905-1906, 95-97; *Fifteenth Biennial Report of the State Engineer to the Governor of Colorado* 1909-1910 (Denver: Smith-Brooks Printing Company, 1911), 156.

[90] State Highway Commission Proceedings 1 (20 July 1910): 49.

[91] Bartlett, 4.

[92]*Fourteenth Biennial Report of the State Engineer to the Governor of Colorado* 1907-1908 (Denver: Smith-Brooks Printing Company, 1909), 80-81.

[93]*Fourteenth Biennial Report*, 81.

[94]*Fifteenth Biennial Report of the State Engineer to the Governor of Colorado* 1909-1910 (Denver: Smith-Brooks Printing Company, 1909), 153, 159.

[95]State Highway Commission Proceedings 1 (17 May 1910): 19-24.

[96]*Second Biennial Report of the State Highway Commission* 1912-1913 (Denver: Smith-Brooks Printing Company, 1913), n.p.

[97]*Second Biennial Report*, n.p.; *Third Biennial Report of the State Highway Commission* (Denver: Smith-Brooks Printing Company, 1915), n.p.; *Fourth Biennial Report of the State Highway Commission* (Denver: Smith-Brooks Printing Company, 1917), n.p.; Eagle County Commissioners' Record, Book 5 (2 April 1912), 347; (3 Septem-ber 1912), 361; (15 September 1914), 458; (11 November 1914), 469; (14 December 1914), 471; Book 6 (11 January 1915), 3; (16 November 1915), 27; (17 April 1916), 45; (5 September 1916), 53; (3 October 1916), 58; (11 November 1916), 70-71; (27 November 1916), 65; (5 March 1917), 77; (7 May 1917), 83. Located at Eagle County Clerk's Office, Eagle, Colorado. All three bridges were built by the Pueblo Bridge Company using the patented design of Daniel Luten. All remain in place today, but the Wolcott Bridge is the only one still carrying vehicular traffic.

[98]*First Biennial Report of the State Highway Commission* 1910-1911 (Denver: Smith-Brooks Printing Company, 1911), n.p.

[99]*Second Biennial Report*, n.p.

[100]*Fourth Biennial Report of the State Highway Commission* 1916-1917 (Denver: Eames Brothers, 1917), n.p.

[101]Warren James Belasco, *Americans on the Road: From Autocamp to Motel, 1910-1945* (Cambridge, Massachusetts: MIT Press, 1981).

[102] "First Survey of Denver-Omaha Auto Highway Is Completed," *Denver Post*, 27 July 1911; Carol Ahlgren, "Dry, Long and Dusty: The Detroit-Lincoln-Denver (DLD) Highway in Nebraska." *Society for Commercial Archeology Journal* 15:2 (Fall 1997).

[103]Drake Hokanson, *The Lincoln Highway: Main Street Across America* (Iowa City, Iowa: University of Iowa Press, 1988), 6.

[104]Ibid., 12.

[105]Ed Orazem, "National Old Trails Highway," *Colorado Highways*, 3:8 (August 1924), 14.

[106]Hokanson, 95; "Colorado Road Map" (Chicago: Geographical Publishing Company, 1911); Ben Blow, "The Victory Highway," *Colorado Highways* 4:12 (December 1925), 6-7.

[107]Wiley, 25.

[108]Wiley, 25-26.

[109]Ibid.

110 "Bridges." *The WPA Worker* 1:2 (July 1936).

111 "A Grand Panorama of Colorado Through Works Progress Administration." *The WPA Worker* 1:3 (August 1936).

112 Ralph J. O' Rourke, "Works Progress Administration Highway Projects in Colorado." *University of Colorado Highway Conference,* March 1936, n.p.

113 Lois Craig, *The Federal Presence: Architecture, Politics, and Symbols in United States Government Buil-ding* (Cambridge, Massachusetts: MIT Press, 1978), 353.

114 "Ceremonies Mark Opening of Denver-Colorado Springs Pavement," *Colorado Highways* 7:8 (August 1928): 3-4, 11; Marion C. Wiley, *The High Road* (Denver: Colorado Department of Highways, n.d), 41.

115 John E. Furlong, ed., *Suggestions and Recommendations to Stimulate the Movement and Parking of Vehicles in Denver and Adjacent Areas* (Denver: City Club of Denver, 1942), 6, 22-28.

116 Wiley, 41; Clark Secrest, "The Valley Highway: The Road That Colorado Loves to Hate." *Colorado Heritage*, 1995: 37-48.

117 Crocker and Ryan, Consulting Engineers, *The Valley Highway: A North-South Limited-Access Highway through Denver* (Denver: Crocker and Ryan, 1944), 13.

118 Ibid., 2-3.

119 Ibid., 18-21.

120 Ibid., 21.

121 Ibid., 23.

122 Ibid., 43.

123 Ibid., 43-44, 50-60. Crocker and Ryan stated:

> The more common type of interchange is the one known as the cloverleaf. This type of construction makes possible the elimination of left turns on both highways with the use of only one structure. For this reason it is usually the least expensive type of interchange for two major highways. For effective operation all ramps should consist of a single lane only and because of this the intensity of turning movements that can be accommodated is limited.

124 Ibid., 49-50.

125 Wiley, 43; "Plans for Postwar Superhighways Are Outlined by Denver," *Denver Post*, 12 July 1945.

126 Wiley, 43; Secrest, 40; "$2,230,221 Lowest Bid Submitted for Building First Leg of Valley Road," *Denver Post*, 19 October 1948; "Low Bid Announced for Valley Highway," *Rocky Mountain News*, 22 October 1948; "Contract OK'd for First Leg of Valley Highway," *Denver Post*, 25 October 1948.

127 Wiley, 43; "U.S. Aid Sought on Valley Road," *Denver Post*, 5 July 1949; "City Saves 2½ Millions on Road," *Denver Post*, 29 July 1949; "U.S. Funds Diverted to City," *Denver Post*, 29 July 1949.

[128]Sam Lusky, "Two Big Valley Highway Projects Take Shape," *Rocky Mountain News*, 11 December 1949. Lusky reported:

> Goals of the system, as outlined by its engineers, are the free flow of traffic with no interruption from slowdowns, stops and bottlenecks; maintenance of a high average speed; elimination of congestion and road hazards. Free-flow access will be provided at all major intersections, with less complete facilities at intermediate points; traffic alongside the highway will be accommodated by service roads; off-highway provisions will be made for emergency stops, service needs and terminal facilities, and the way will be left open for future increases in traffic needs.

[129]Ed Oschmann, "Right-of-Way Compact Speeds Valley Road," *Rocky Mountain News*, 12 February 1950; John W. Buchanan, "$3-Million Savings Seen in Valley Highway Cost," *Denver Post*, 12 February 1950.

[130] "Air View of Valley Highway." *Rocky Mountain News*, 4 July 1950; Bill Brenneman, "Feel Brave? Try Traveling Valley Highway!" *Rocky Mountain News*, 27 November 1950; Secrest, 41.

[131]Crocker and Ryan, 60.

[132]Ibid., 60.

[133]*Commemorating the Opening of the Denver Valley Highway, November 23, 1958* (Denver: Colorado Department of Highways, 1958), 10; "New River Span Makes Beautiful Picture," *Rocky Mountain News*, 31 December 1950; John W. Buchanan, "Engineers O.K. Start in Section in South Denver," *Denver Post*, 9 August 1951.

[134] "Valley Highway's South Unit Next, Watrous Says," *Rocky Mountain News*, 11 April 1951.

[135]Wiley, 44; Nello Cassal, "Colorado Blvd. Cloverleaf Next Valley Highway Unit," *Denver Post*, 12 July 1953; "Valley Highway Section Opens on Colorado," *Rocky Mountain News*, 21 May 1954.

[136] "Bids for Valley Highway Extension Sought by State," *Denver Post*, 30 September 1954; Tom Gavin, "Denver Asks $28 Million State Road Aid," *Rocky Mountain News*, 1 December 1954; "Dream Come True: Denver's Valley Highway Is Completed," *The Engineers' Bulletin* 42:12 (December 1958): 8-10.

[137] "Newest Valley Highway Link Completion Due in 2 Months," *Denver Post*, 24 July 1955; "New Valley High-way Overpass Open to Traffic," *Denver Post*, 9 September 1955; "Valley Highway Section to Open," *Rocky Mountain News*, 9 November 1955; "State to Open Newest Part of Valley Highway Nov. 10," *Rocky Mountain News*, 23 October 1955. A *News* reporter drove along the newly opened stretch and "found smooth surface, gentle curves and scarcely noticeable grades. The access roads were easy to get onto from the main strip, and even without the signs common to other sections of the Valley Highway they were easy to distinguish from the main road."

[138]David Stolberg, "Valley Highway Contract Approved," *Rocky Mountain News*, 23 May 1956; Tom Hutton, "Major Contract Let for Denver's Big Valley Highway," *Denver Post*, 6 June 1956.

[139]Reva Cullen, "$8.5 Million Outlay Cuts Year Off Valley Highway Finish," *Denver Post*, 29 November 1956; Tom Gavin, "$33 Million Valley Highway Near Finish after 10 Years," *Rocky Mountain News*, 19 January 1958; David Stolberg, "Valley Highway Near Completion," *Rocky Mountain News*, 26 October 1958.

[140]Wiley, 45; David Stolberg, "Valley Highway Near Completion," *Rocky Mountain News*, 26 October 1958; Maxine Lowry, "Ceremonies Mark Valley Highway Completion," *Denver Post*, 24.

[141]Wiley, 44-45; Secrest, 41-42; *Commemorating...*, 2; Tom Gavin, "$33 Million Valley Highway Near Finish after 10 Years," *Rocky Mountain News*, 19 January 1958.

[142]Colorado Highway Department, *Commemorating the Opening of the Monument Valley Freeway, Colorado Springs*, July 1, 1960.

[143]Ibid.

[144]Colorado Department of Highways, *Commemorating the Opening of the Pueblo Freeway, July 1, 1959.*

[145]Wiley, 50-51.

[146]Colorado Department of Highways, *Commemorating the Opening of the Colorado-Wyoming Link of Interstate 25*. October 11, 1964; Joe Garner, "Interstates Split the Divide," *Rocky Mountain News*, 12 March 2000.

Property Type: Timber stringer and truss bridges

Description: Timber has been used for bridge construction in Colorado for as long as there have been bridges. The railroads used timber extensively when building through the mountains in the 19th century, constructing spindly, multiple-span trestles when stream conditions allowed for many pile bent piers, or erecting timber/iron combination trusses when longer spans were required. Bridges built for roadway use followed the same structural principals and took many of the same forms as railroad bridges. Like the railroads, early Colorado vehicular roads made extensive use of timber stringer bridges, and for the same reasons. Early toll-road operators and county road crews typically avoided building bridges when they could, but when they could not, they built as cheaply as possible, and timber pile bridges were the cheapest and most quickly completed structures that could be built in the 19th and early 20th centuries.

During the 1910s the Colorado Highway Commission generally eschewed timber trestles in favor of concrete and steel construction, and the Commission attempted to direct the counties away from timber construction as well. By the 1920s, however, when the Highway Department needed to build numerous small-scale drainage structures over thousands of miles of newly designated highways, the SHD embraced timber work, if not enthusiastically, then certainly comprehensively. During the Depression, when labor was more plentiful than materials, and during World War II, when strategic materials such as concrete and steel were embargoed by the government, timber was used extensively by the Highway Department for bridge construction. The trend continued into the 1950s, and timber pile bridges continue to be built today, but primarily at secondary locations such as forest roads.

Wagon bridges were configured similarly to railroad structures, with parallel lines of wooden beams laid over the piers and abutments in single- or multiple-span configurations. The substructures were typically timber pile bents, but stone masonry, concrete, steel pile bents, or log cribs were used as well. Like railroad bridges, timber stringer structures for wagon use rarely exceeded 30 feet in length. Those stringer bridges with longer spans were sometimes reinforced with metal tension rods attached under the beams to form what were called "jack trusses." The decks and guardrails of timber trestles were almost always made up of wooden members.

The primary difference between railroad bridges and wagon bridges lay in the stoutness of their construction. Railroad bridges were engineered and built to carry heavy loads while maintaining a high degree of rigidity. Wagon bridges were required to carry far lighter loads and did not need to be as unyielding as railroad structures. Virtually all of the earliest roadway structures in Colorado were built of timber, and many were dangerously flimsy. Often poorly constructed and unevenly maintained, these rudimentary timber structures typically washed out in floods or collapsed under load. Thousands of timber trestles were built in Colorado to cross everything from irrigation ditches to the Arkansas and Platte rivers. So ubiquitous were timber stringer structures, that they have historically been the most common bridge type built in Colorado by a wide margin.

United States Department of the Interior
National Park Service

National Register of Historic Places
Continuation Sheet

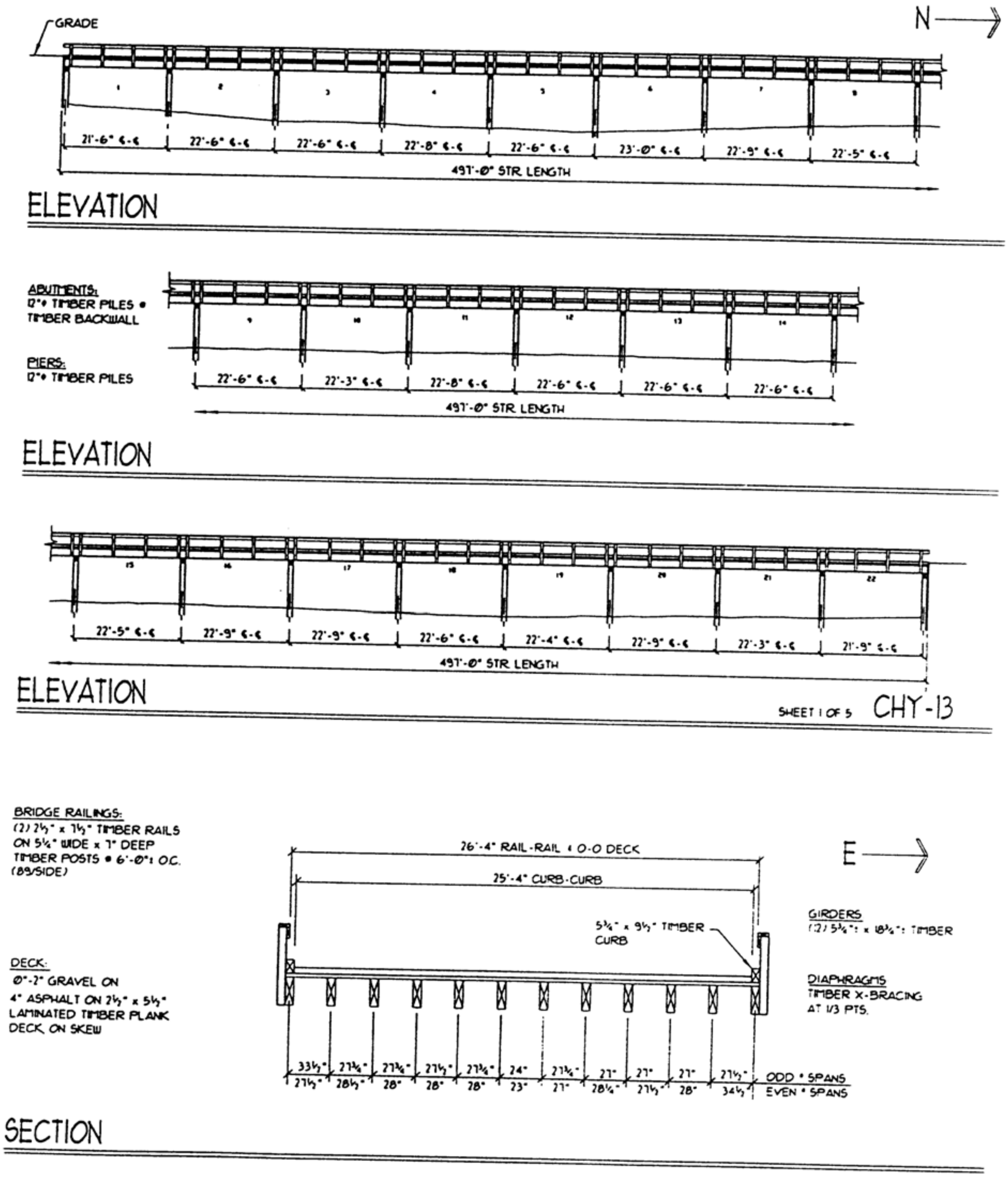

Figure 1. Example of timber stringer bridge. Big Sandy Creek Bridge [5CH157], Cheyenne County, Colo. (Colorado Dept. of Transportation).

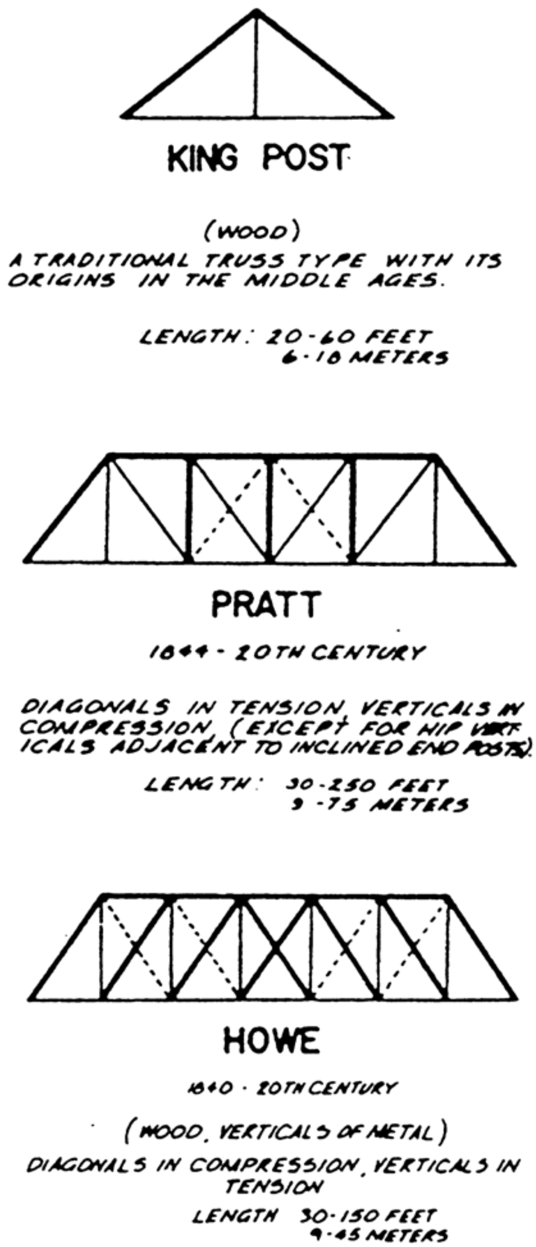

Figure 2. King Post, Pratt, and Howe trusses, from poster produced by Historic American Engineering Record.

Because of their inherently short life spans, no timber trestles for vehicular use are known to have survived from the 19th or early 20th centuries. The timber bridges found today on Colorado’s roads typically date from the 1930s, 1940s and 1950s. The superstructural technology between the early and later bridges has remained essentially unchanged, with the only difference being the sizes of the members. The bridges of the mid-20th century tend to have more substantial substructures, however, relying more on concrete or steel substructures than their predecessors. Depression-era agencies such as the Works Progress Administration and the Civilian Conservation Corps worked extensively in timber, for reasons of both economy and aesthetics. During the 1930s timber was still relatively easy to obtain and treat against decay, and it was an ideal construction material for use by gangs of sometimes poorly trained men. Moreover, it fit well within the rustic design aesthetic embraced by these agencies and could be fashioned into architecturally expressive forms with only rudimentary skills. The WPA in Colorado built a wide range of wooden structures, ranging from the massive trestles over the rivers of the northeast to single- or double-span structures with artistic stone substructures and decorative guardrails. In addition, a great many other timber pile bridges were built by the Highway Department in the 1930s, using traditional bidding and contracting procedures.

Though by far the most common bridge type, the timber stringer was not particularly sophisticated and was limited to crossings that permitted the use of relatively short spans. More technologically innovative was a bridge class that has been termed “primarily an American achievement”—the truss. Wood was used on the first railroad trusses in Colorado, combined with wrought iron rods to form Howe combination trusses. Patented by William Howe of Massachusetts in 1840, the Howe truss featured wooden diagonals that acted in compression and iron verticals in tension. Another important truss design, patented by Thomas and Caleb Pratt in 1844, was characterized by upper chords and vertical members acting in compression and lower chords and diagonals that acted in tension. Howes and Pratts were by far the most common of the railroad truss designs, accounting for over 95 percent of railroad trusses built in Colorado. Narrow-gauge railroads such as the Rio Grande Southern and the Denver & Rio Grande used them extensively in the mountains wherever the stream conditions precluded the use of trestles.[1]

Howes and Pratts were used extensively for wooden wagon bridges as well, in both pony and through configurations. Like the railroad trusses, they typically featured timber compression members and iron or steel tension rods. The most common timber truss type in Colorado, though, was the kingpost. With its inclined endposts, straight lower chord and single vertical at mid-span, the kingpost formed a simple triangular web comprised of two equal panels. When the roadway was carried beneath the truss in a through configuration, the endposts acted in compression and the vertical and lower chords in tension.

The kingpost's origins are ancient and obscure. Its symmetrical triangular form lent itself naturally to timber roof framing, where the truss was first used in the Middle Ages. In 1570 Italian architect Andrea Palladio described a simple kingpost truss bridge in his general treatise on architecture, *I quattro libri della architettura;* he attributed its source to well-established antecedents.[2] Using Palladio's work (translated into English in 1742) and their own empirical designs, early American carpenters constructed kingpost bridges at minor crossings throughout the East. The technology spread westward with the pioneers in the late 18th and early 19th centuries. As a result, uncounted timber kingposts were built on the region's early roads. The truss form remained unchanged as its construction evolved from the vernacular to the industrial in the 19th century, with the principle changes involving the materials used: timber, timber/iron, iron, steel.

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[1] T. Allen Comp and Donald Jackson, “Bridge Truss Types: A Guide to Dating and Identifying,” Technical Leaflet 95 (Nashville, Tennessee: American Association for State and Local History, 1977).

[2] David Plowden, *Bridges: The Spans of North America* (New York, New York: W.W. Norton and Company, 1974), 34-35.

The kingpost's simplicity and straightforward determination of stresses in the individual members made it an ideal subject to illustrate bridge design. Squire Whipple delineated a kingpost truss in his 1847 essay on bridge building, the first such work to rationalize bridge design using scientific principles. Similarly, Merriman and Jacoby, in their *Text-Book on Roofs and Bridges* [1906], and J.A.L. Waddell, in his *Bridge Engineering* [1916]—two of the most influential bridge engineering texts of their time, employed the kingpost to illustrate the principals of static design. "The secret of economical and efficient truss arrangement lies in the panel system," stated Merriman and Jacoby, "which may be regarded as having been developed from the king-post truss."[3] Timber trusses suffer from the same structural shortcomings that timber trestles did, and their numbers have been decimated by replacement. As a result, only a few remain in place today of what amounted to hundreds of such structures in Colorado.

Significance: Timber stringer and truss bridges in Colorado may be eligible for listing in the National Register under Criterion A for their association with events that have made a significant contribution to the broad historical patterns of the country, the state, or the region. Specifically, this includes those bridges that have played an important role in the development of the state's highway transportation system and, hence, in the settlement of the area. For example, a structure might be significant for its association with a particular route, such as the Greeley-Denver Road, because it was built with assistance from the State Highway Commission in its formative years, or because it was built by a Federal Depression-era relief program. A bridge may, in addition, be eligible under Criterion B for its association with a significant person, as long as the "significant person" was not the designer or builder of the bridge. A bridge can be eligible by virtue of its designer or builder, but this falls under Criterion C. Indeed, most eligible bridges in Colorado qualify under Criterion C as structures of engineering significance. This can encompass a broad range of considerations. For instance, a bridge can qualify under Criterion C as a well-preserved example of a common type, or as an important variation.

Timber stringer bridges are sufficiently common in Colorado that to be considered eligible for listing in the National Register under Criterion C, a structure from this property type must have definitive historical documentation and some superlative feature that distinguishes it from its peers. Some examples of this are notably early construction date, exceptionally long span length, unusually high span number, or well-executed architectural design.

Registration Requirements: The period of significance for timber stringer and truss bridges in Colorado begins in 1880, the earliest construction date covered in this MPDF. The period of significance ends in 1952, the fifty-year date after which bridges must possess exceptional significance. Alterations made during the period of significance may be considered part of the bridge's historic fabric. Such changes may or may not be in keeping with the bridge's original design. Integrity of the structure's historic materials and design is essential for the bridge to qualify for the National Register under any criterion. Since timber stringer bridges are rarely moved, integrity of location is a given. Timber bridges may be eligible for the National Register under Criterion B for their association with a significant person, but this is rare. Most often, these bridges will have significance under Criteria A or C.

[3] Squire Whipple, *A Work on Bridge Building: Consisting of Two Essays, One Elementary and General, the Other Giving Original Plans, and Practical Details for Iron and Wooden Bridges* (Utica, New York: H.H. Curtis, 1847), pages 6-7; Mansfield Merriman and Henry S. Jacoby, *A Text-Book on Roofs and Bridges*, 3 volumes (New York New York: John Wiley and Sons, 1906), page 6.

Specific requirements under Criterion A:

1. Early and/or prominent product of the Colorado State Engineer's Office or Colorado Highway Department:
In 1881 the Colorado State Legislature established the State Engineer's Office and funded specific bridge construction projects under the Internal Income Fund. Many of these bridges were timber trestles or trusses, although none are known to remain today. In 1910 the state legislature formed the Colorado Highway Commission (and its successor, the Colorado Highway Department). Numerous timber stringer bridges—but no trusses—were designed by the Highway Commission in the 1910s, although none are known to remain today.

2. Outstanding example of product of a Federal work relief program of the Depression era:
Federal work programs in the 1930s and early 1940s, particularly those funded by the WPA, led to construction of a number of timber stringer bridges in the state. The most significant display careful craftsmanship and creative design.

3. Association with a significant route or event (regional or statewide):
If the construction of or improvements to a route or highway helped open up a region for travel and commerce, or contributed to increased development and prosperity in nearby communities, the route or highway might be considered eligible under Criterion A. The bridges along this route, if unaltered from the period of significance, may also be eligible under Criterion A for their association with significant events. Similarly, if a bridge was built as part of a significant event, such as when the State Highway Department launched a campaign to improve the safety of bridge crossings over railroad features, it may be eligible under Criterion A for its association with that specific campaign.

4. Association with civic improvement projects, such as the City Beautiful movement:
Bridges built as part of a specific aesthetic or planning initiative in a community might be considered significant under Criterion A as local expressions of a national movement.

Specific requirements under Criterion C:

1. Early and/or representative multiple-span timber stringer bridges:
Timber stringer bridges built before 1920 are sufficiently rare in Colorado that any example that has maintained physical integrity is considered eligible for the National Register. Additionally, although Colorado once had numerous multi-span timber bridges, only eleven such structures with ten or more spans have been identified from the historic period by the statewide historic bridge inventory. These are considered the most significant examples of their type.

2. Representative example of timber truss:
Timber truss bridges are sufficiently rare that any extant example, regardless of structural integrity, is considered eligible for the National Register.

3. Bridge with exceptional aesthetic merit:
Most bridges built in the state, particularly timber structures, are strictly utilitarian. Occasionally, however, a structure stands out by virtue of its design or because of the quality displayed in its construction. The interrelationship of a bridge and its site can also have aesthetic value as well, if the bridge demonstrates a significant engineering achievement due to topographical conditions or constraints.

Property Type: Concrete slab and girder bridges

Description: With its deck and superstructure poured integrally in a single flat sheet over steel reinforcing, the simple concrete slab is the most rudimentary of the concrete bridge types. A concrete girder bridge looks something like a slab and features parallel lines of concrete beams poured integrally with the deck slab. Girder structures were generally built with the beams aligned beneath the roadway, but they could be configured with deep girders flanking the roadway on both sides, much like thick guardrails. A step up from the slab in terms of technological advancement, girders in either deck or through configurations could economically reach longer spans than slabs. Both structural types were built in single-span configurations with simply supported bearing, or with multiple spans strung together either simply or continuously over concrete piers. Because concrete acts well under compressive loading but poorly under tension, concrete slabs and girders rely heavily on steel reinforcing along their lower surfaces, where the tensile stresses are greatest. This reinforcing typically takes the form of square, twisted, or deformed reinforcing bars that extend the length of the span. Concrete slabs are generally limited to span lengths of 30 feet or less; girders can be built with spans in excess of 100 feet, but in Colorado girders built before the mid-1950s rarely exceeded 50 feet.

The first reinforced concrete girder bridge was built in France in 1893. Spans of up to 85 feet appeared by 1904 in Europe, the leader in this design, and in America concrete girders began to receive acceptance for highway use between 1900 and 1910. A few concrete slab or girder bridges were built in Colorado by the counties, the railroads, and the larger cities after the turn of the century. Between 1905 and 1911 the State Engineer’s Office erected several concrete girder structures, two of which—the Brown’s Cañon Bridge in Chaffee County and the Capulin Bridge in Conejos County—are still in place as the oldest intact examples of their type in the state. Their use was relatively limited, however, until the Colorado Highway Commission began designing bridges in 1910. Most of the Commission’s first bridges that year were concrete slab or girder structures. In addition to 20-foot-span slabs in Arapahoe and Douglas counties and a 30-foot girder in Montezuma County, the agency designed and built multiple-span structures over Kiowa and Box Elder creeks in Adams County and Bijou Creek in Morgan County.[4] With a few exceptions, the counties were slow in accepting concrete construction, however. This began to change gradually around 1917, when the Commission issued its first standard plans for reinforced concrete slab and girder bridges. Widely distributed among the counties, these designs featured haunches that were angled or arched to decrease the effective span length by cantilevering, and their roadways were bounded on both sides by solid concrete parapets or concrete post-and-beam guardrails.[5]

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[4] Colorado State Highway Commission, *First Biennial Report* 1910-1911 (Denver: Smith-Brooks Printing Company, 1911); *Second Biennial Report* 1911-1912 (Denver: Smith-Brooks Printing Company, 1912).

[5] Colorado State Highway Commission, *Third Biennial Report* 1913-1914 (Denver: Smith-Brooks Printing Company, 1915); *Fourth Biennial Report* 1915-1916 (Denver: Eames Brothers, 1917); J.E. Maloney, “Standard Bridge Plans,” *Colorado Highways Bulletin* 2:11 (November 1919).

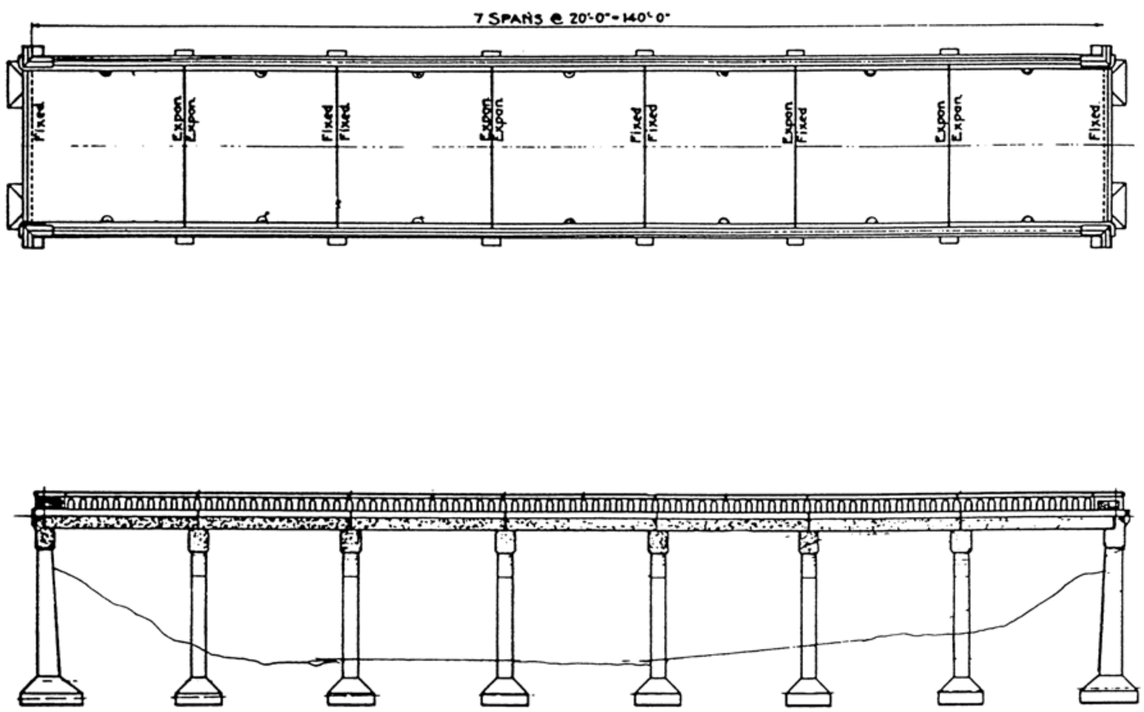

Figure 3. Example of concrete slab bridge. Spring Creek Bridge [5KC168], Kit Carson County, Colo. (Colorado Dept. of Transportation).

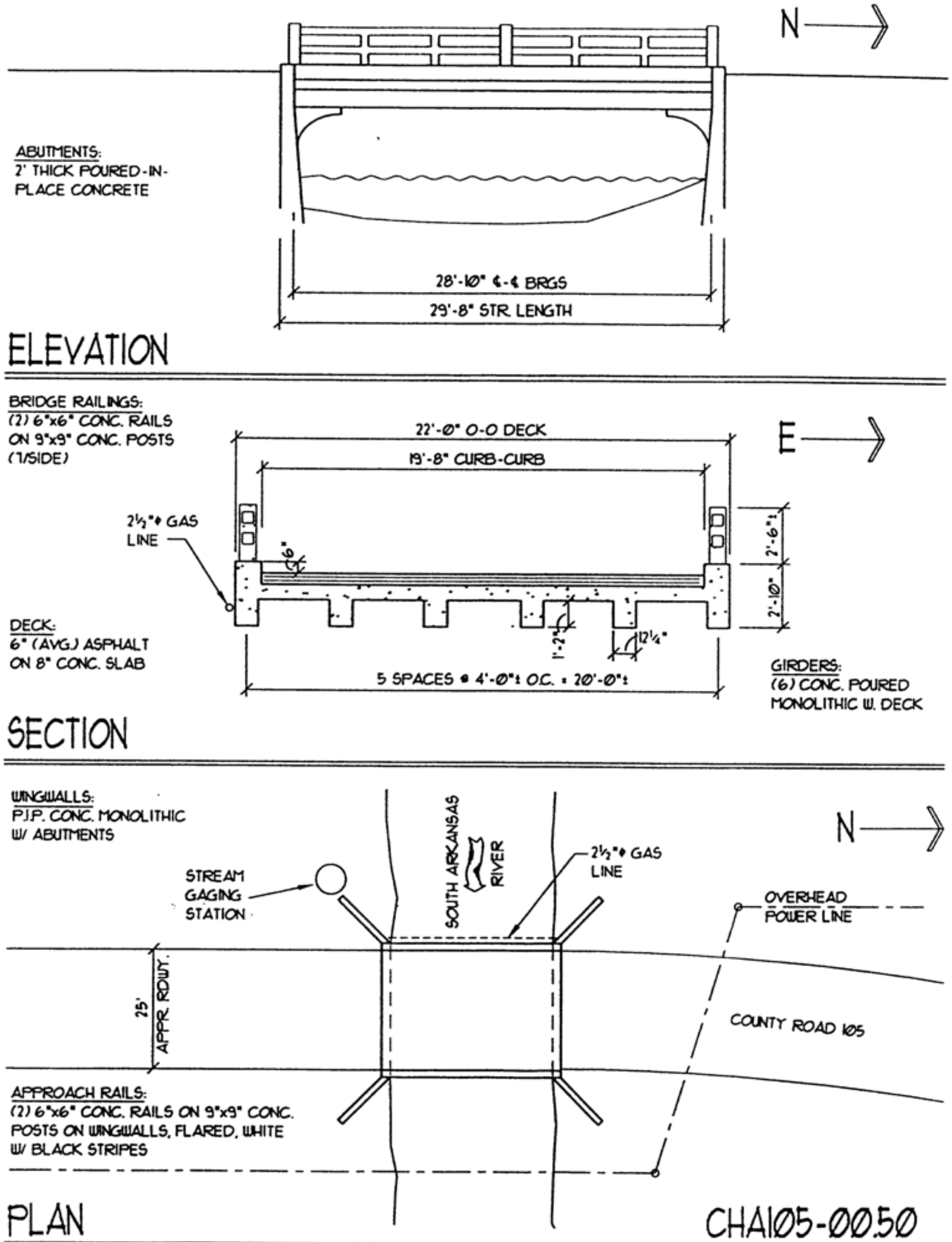

Figure 4. Example of concrete deck girder bridge. South Arkansas River Bridge [5CF1054], Chaffee County, Colo. (Colorado Dept. of Transportation).

Concrete slab and deck girder bridges received more widespread use in the 1920s and 1930s, as the Highway Department assumed more responsibility for bridge construction in the state. One type used on a tentative basis in the 1920s was the cantilevered concrete girder bridge, with arched haunches. Noteworthy examples of this can still be found in El Paso, Fremont and Las Animas counties. The main advantages of concrete slabs and girders were structural rigidity under load and the capability for subsequent widening by adding onto one or both sides of the roadway. Despite these advantages, slabs or girders were never built in abundance in Colorado, because the Highway Department preferred steel stringer construction to concrete girders.

There were no noteworthy technological advancements made on these structural types during the 1940s. In the 1950s the concrete deck girder experienced a notable resurgence in popularity, as the Highway Department built scores of flat-beamed girders at crossings throughout the state. Additionally, at this time CHD introduced a new type of long-span concrete girder design, with the beams arched parabolically over their span and supported by concrete spill-through piers. First used at a few isolated locations around the state, including along SH 119 in Boulder County, these became the standard design for highway overpasses and underpasses when Colorado built its interstate highway system in the late 1950s and 1960s.

Significance: Concrete slab or girder bridges in Colorado may be eligible for listing in the National Register of Historic Places under Criterion A for their association with events that have made a significant contribution to the broad historical patterns of the country, the state, or the region. Specifically, this includes those bridges that have played an important role in the development of the state's highway transportation system and, hence, in the settlement of the area. For example, a structure might be significant for its association with a particular route, such as the Pueblo-Colorado Springs Highway, because it was built with assistance from the State Highway Commission in its formative years, or because it was built by a Federal Depression-era relief program. A bridge may, in addition, be eligible under Criterion B for its association with a significant person, as long as the "significant person" was not the designer or builder of the bridge. A bridge can be eligible by virtue of its designer or builder, but this falls under Criterion C. Indeed, most eligible bridges in Colorado qualify under Criterion C as structures of engineering significance. This can encompass a broad range of considerations. For instance, a bridge can qualify under Criterion C as a well-preserved example of a common type, or as an important variation.

Concrete slab and deck girder bridges are sufficiently common in Colorado that to be considered eligible for listing in the National Register under Criterion C, structures from these property types must have definitive historical documentation and some superlative feature that distinguish them from their peers. Some examples of this are notably early construction date, exceptionally long span length, unusually high span number, or well-executed architectural design.

Registration Requirements: The period of significance for concrete slab and girder bridges in Colorado begins in 1900, the approximate date for the state's earliest examples of these structural types. The period of significance ends in 1952, the fifty-year date after which bridges must possess exceptional significance. Alterations made during the period of significance are considered part of the bridge's historic fabric. Such changes may or may not be in keeping with the bridge's original design. Integrity of the structure's historic materials and design is essential for the bridge to qualify for the National Register under any criterion. Since concrete slab and girder bridges are rarely moved, integrity of location is a given. Slab and girder bridges may be eligible for the National Register under Criterion B for their association with a significant person, but this is rare. Most often, these bridges will have significance under Criteria A or C.

Specific requirements under Criterion A:

1. Early and/or prominent product of the Colorado State Engineer's Office or Colorado Highway Department:
In 1881 the Colorado State Legislature established the State Engineer's Office and funded specific bridge construction projects under the Internal Income Fund. Some of the later bridges built under this program were concrete structures, and two are known to remain today. In 1910 the state legislature formed the Colorado Highway Commission (and its successor, the Colorado Highway Department). Numerous concrete slab and deck girder were designed by the Highway Commission in the 1910s and early 1920s, and a few remain in place today.

2. Outstanding example of product of a Federal work relief program of the Depression era:
Federal work programs in the 1930s and early 1940s, particularly those funded by the Works Progress Administration, led to construction of a number of concrete slab and deck girder bridges in the state. The most significant display careful craftsmanship and creative design.

3. Association with a significant route or event (regional or statewide):
If the construction of or improvements to a route or highway helped open up a region for travel and commerce, or contributed to increased development and prosperity in nearby communities, the route or highway might be considered eligible under Criterion A. The bridges along this route, if unaltered from the period of significance, may also be eligible under Criterion A for their association with significant events. Similarly, if a bridge was built as part of a significant event, such as when the State Highway Department launched a campaign to improve the safety of bridge crossings over railroad features, it may be eligible under Criterion A for its association with that specific campaign.

4. Association with civic improvement projects, such as the City Beautiful movement:
Bridges built as part of a specific aesthetic or planning initiative in a community might be considered significant under Criterion A as local expressions of a national movement.

Specific requirements under Criterion C:

1. Early and/or representative concrete slab and deck girder bridges:
Concrete slab and deck girder bridges built before 1920 are sufficiently rare in Colorado that any example that has retained structural integrity is considered significant. Those built after 1920 with definitive documentation are considered significant on the basis of superlative features (i.e., exceptionally long span length, unusual number of spans, uncommonly good state of preservation). Concrete slabs or parabolic concrete girders built after 1952 are considered exceptionally significant if they were prototypes for this structural configuration.

2. Representative example of concrete through girder:
Concrete through girder bridges are sufficiently rare in Colorado that any intact example is considered significant.

3. Bridge with exceptional aesthetic merit:
Most bridges built in the state are strictly utilitarian. Occasionally, however, a structure stands out by virtue of its design or because of the quality displayed in its construction. This does not include standard-design concrete guardrails by the Highway Department, however. The interrelationship of a bridge and its site can also have aesthetic value as well, if the bridge demonstrates a significant engineering achievement due to topographical conditions or constraints.

Property Type: Concrete, stone, and steel arch bridges

Description: The concrete arch relies on two ancient technologies—concrete construction and the arch form—which date to Roman precedents. Although the Romans had developed a form of hydraulic cement, there is no evidence to suggest that they used it for bridge construction. After Rome fell, concrete technology was lost for over a thousand years, until it later reappeared in England. British engineer George Semple was apparently the first to use hydraulic cement for bridge construction, on pier foundations for the Essex Bridge in Dublin, built in the mid-16th century. In 1824 Englishman Joseph Aspdin developed an artificial cement composed of a calcinate mixture of limestone and clay. Aspdin called his concoction Portland cement after Portland on Devonshire, the source for his limestone. Almost 50 years later, American David O. Saylor patented his own type of Portland cement in 1871 and built the country's first cement manufacturing plant near Coplay, Pennsylvania.[6]

The first documented use of concrete on an American bridge, like Semple's Essex Bridge, was not for a superstructure at all but for the foundations of the Erie Railroad’s Starrucca Viaduct, completed in 1848.[7] John Goodrich was probably the first in this country to use concrete as the principal material for the spans of a bridge. A modest 31-foot structure built in 1871, his Cleft Ridge Park Bridge in Brooklyn’s Prospect Park used concrete because it was intended to be an ornamental structure and concrete was cheaper than stone. Soon other concrete spans began to appear in this country. From 1890 to 1900, over 150 reinforced concrete spans were built on scales ranging from minimal to monumental.[8]

These early structures were built of unreinforced, or mass, concrete, which has the same structural properties as stone. Although far stronger than either iron or wood in compression, unreinforced concrete has virtually no tensile strength. Its use in bridge work was therefore limited to an ancient structural form derived from stone masonry—the arch. The arch rib or ring functioned essentially as an extended curved column, under compression over its entire length. Further, as a beam, it had to resist the bending and shear stresses caused by shifting live loads applied to the bridge deck and differential expansion and contraction caused by the weather. “It was a comparatively easy change from the stone voussoir arch to concrete monolithic or voussoir construction,” engineer Frank Barber stated in 1911.[9]

It would not be until the end of the 19th century that engineers would begin to understand and develop the plastic properties of concrete and use it as something more than just a cheap imitation of stone. To address concrete's inherent tensile shortcoming, American engineer W.E. Ward demonstrated in 1871 that the material could be strengthened to resist tension by embedding iron bars in it. Such a composite configuration would combine the compressive strength of concrete with the tensile properties of iron. The concrete would thus protect the reinforcing from corrosion and would provide an economical and technological alternative to an all-metal solution by reducing the amount of iron needed to bear the weight.

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[6]Caleb Hornbostel, *Construction Materials: Types, Uses and Applications* (New York: John Wiley and Sons, 1978), 205; Pedro Guedes, *Encyclopedia of Architectural Technology* (New York: McGraw-Hill Book Co., 1979), 253-255.

[7]Plowden, *Bridges,* 297.

[8]Ibid.; “The Present Status of Reinforced Concrete Bridges,” *Engineering Record* (13 August 1910): 169-170; Henry S. Jacoby, “Recent Progress in American Bridge Construction,” *Scientific American Supplement, 19 July 1902, 22199.*

[9]Frank Barber, “Characteristics of Long-Span Concrete Bridges,” *Engineering Record* (8 April 1911): 397.

The application of this discovery to large-scale bridge construction should have been immediately apparent, but it was not until ten years later that S. Bissel received the first American patent for concrete reinforcing. The first reinforced concrete bridge built in this country was the Alvord Lake Bridge in San Francisco's Golden Gate Park, completed in 1889. Designed by Ernest Ransome with a modest 35-foot span, it was an otherwise unremarkable structure and still stands today. It was only after the turn of the century that concrete began to rival stone for long-span archbuilding. Engineers by then had begun to stretch the technological limits of concrete construction dramatically with new methods of forming, centering, and reinforcing the arches. In 1904 a bridge in Grunwald, Germany, was built with a span of almost 230 feet. In 1908 E. Morsh completed a 259-foot bridge over the gorge of the Gmundertobelbruke in Switzerland. That same year American engineer George Webster completed the Walnut Lane Bridge in Philadelphia. Called the largest concrete arch in the world at its completion, it featured an unreinforced 233-foot main arch. By the end of 1910, 19 concrete arches had been built in the world with spans in excess of 150 feet.[10] In 1910 *Engineering Record* described the progress that American engineers had made in concrete bridge construction:

> When it is considered that the first reinforced concrete arch bridge in the United States was built only 21 years ago, the development which has taken place in the design and construction of bridges of this type seems very remarkable. Moreover, the greater part of this growth has been brought about in the last decade. That this movement is still going on is shown by the fact that at frequent intervals descriptions appear in the engineering press of structures which embody new ideas or material modifications of old ones. It is interesting to watch this progress, and especially to see the influence which the materials used have had on the development.[11]

One aspect that all long-span concrete arches shared was their open-spandrel design. For shorter spans, engineers typically employed filled-spandrel arches, with the roadway supported by earth fill poured over the continuous concrete arch ring. But these would be inordinately heavy over long spans, so engineers used open-spandrel arches, which substituted a series of concrete columns for the earth fill, on longer spans. The earliest open-spandrel arches employed single, relatively thin arch ribs that extended continuously over the width of the bridge. Around 1910 engineers began to experiment with multi-rib arches that used several individual ribs in lieu of continuous ribs. There were several advantages to this new structural form. First, less material was used in the individual ribs. Additionally, the floor of a multi-rib bridge could be supported by a single row of columns on each rib, whereas on a continuous-rib design, several rows of columns or even continuous walls were necessary to distribute the weight of the deck evenly over the arch rib. Finally, on ribbed-arch bridges, the outer edge of the floor could be cantilevered beyond the outside ribs, allowing for narrower sub-deck configurations with narrower, more economical abutments.

Colorado generally followed national trends in the construction of its reinforced concrete arches. The first arches appeared in the state around the turn of the century in the urban areas, where rigidity under heavy traffic was important. These earliest structures almost all employed filled-spandrel designs. One of the first concrete arches built in Colorado

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[10] Charles S. Whitney, *Bridges: Their Art, Science and Evolution* (New York: Crown Publishers, 1983), 288; Barber, "Characteristics. . .," 397; "The Walnut Lane Bridge Completed," *Engineering News* (5 November 1908): 497.

[11] "The Present Status of Reinforced Concrete Bridges," 169-170.

was the Commercial Street Bridge in Trinidad, completed in 1905 by Des Moines contractor and engineer James Marsh. Spanning the Purgatoire River, it featured two 70-foot arches and used a design patented that year by Indianapolis engineer Daniel B. Luten. Patterned after an arch reinforcing scheme developed by Austrian engineer Josef Melan, Luten's filled-spandrel arch was the most widely built of the proprietary arch types in America.

Luten's arch was later promoted to Colorado's counties by Fred M. Bullen and his son Joseph, who as proprietors of the Pueblo Bridge Company functioned as licensees to Luten. Operating under a patent royalty agreement to Luten, Pueblo Bridge designed and built Luten arches around the state, particularly in the Arkansas River Valley. Pueblo Bridge extensively promoted Luten's trademark elliptical arch—often called a horseshoe arch because of its distinctive profile—and bid frequently for county bridge contracts. Pueblo Bridge's unceasing self-promotion distinguished the firm as Colorado's most prolific bridge builder in the first two decades of the 20th century. The company built scores of Luten arches of varying sizes in Colorado during the 1900s and 1910s. Of these, 16 remain in place today.

The other proprietary arch design found in Colorado was patented in 1910 by James Marsh, the builder of the Commercial Street Bridge. In contrast with the Luten arch, Marsh's structure carried its deck in a through configuration between two open-spandrel, overhead arches. The arches—called rainbow arches due to their distinctive profile—act in compression, but the hangers and floor beams carry the deck in tension. To make the concrete thus act against its nature, Marsh inserted large amounts of structural steel. His bridges may look like concrete spans, but the arch ribs and hangers carry such heavy, complicated reinforcing that they are, in reality, steel structures encased in concrete. Only one Marsh arch was ever built in Colorado—the Fort Morgan Bridge over the South Platte River, an 11-span structure completed by the Colorado Bridge and Construction Company in 1923.

The Rainbow Bridge and the Luten arches built by Pueblo Bridge were all engineered and based upon patented designs. Other, small-scale concrete arches were built in the state that were more casually derived, using designs that were more empirical in their origin. Perhaps the most noteworthy pocket of arches designed and built by a local contractor was located in Fremont County. Beginning in 1908 Florence-based contractor H.M. Fox built several filled-spandrel concrete arches in town and around the surrounding county, using his own designs. Other such locally designed arches were built in small numbers elsewhere in the state by other contractors during the 1910s and early 1920s.

Around 1917 the Colorado Highway Commission developed its own filled-spandrel arch design and distributed standard plans for it to the county road agencies. Like the reinforced concrete slab and girder bridge standards, though, these arches did not receive widespread acceptance around the state. The Highway Department constructed a number of filled-spandrel arches in the 1920s and 1930s, but this structural type was never built in abundance. In the early 1930s the Highway Department experimented with two-rib, open-spandrel arches at crossings where it would ordinarily have built long-span through trusses. But like filled-spandrel arches, these structures were used sparingly. Arch construction essentially ceased during World War II, with its severe limitations in the use of concrete. After the war the Highway Department began using more efficient concrete bridge designs. The most notable exception to this last trend was the bridge over Cherry Creek in Douglas County, an open-spandrel arch built in 1948 with a span of 232 feet.

Although stone for heavy construction was readily available in Colorado, stone arch bridges were rarely built on the state's wagon roads during the 19th and early 20th centuries. The most noteworthy exception to this is the Main Street Bridge in Durango, a three-span stone arch structure built in 1906. During the 1930s, however, the Works Progress Administration constructed scores of arch structures on roads, particularly in the southeast corner of the state. The

WPA used true stone arches, with the rock voussoirs and arch ribs acting in compression, and faux stone arches, which used multi-plate steel arches and stone veneers. The scale and level of craftsmanship varied widely on these structures, with the Douglas Crossing Bridge in Prowers County at one end of the spectrum and numerous anonymous arch culverts at the other.

Steel arches in Colorado fall into two categories: major steel spans and minor pipe culverts. Bridges built from the former group can be counted on one hand. Only two—the Red Cliff Bridge in Eagle County and the South Platte River Bridge in Denver—remain in place today. The latter group is more numerous and includes several structures built by the WPA beginning in 1936 and later steel pipe culverts built in the 1950s, 1960s and 1970s.

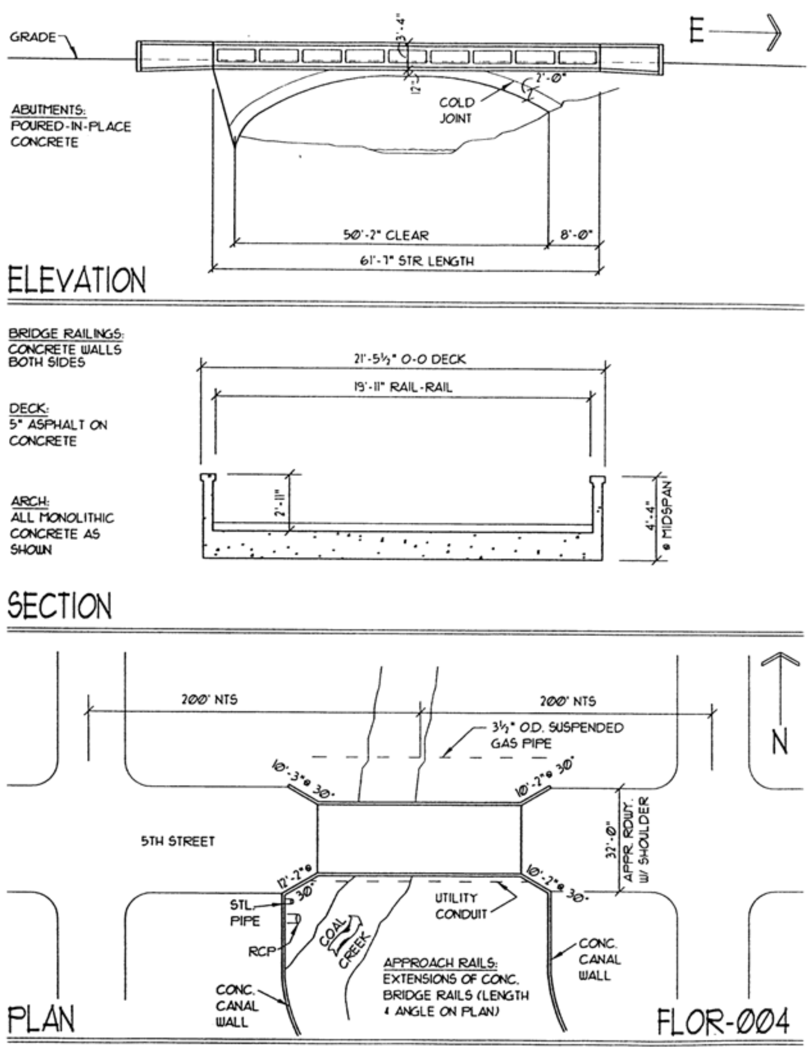

Figure 5. Example of filled-spandrel concrete arch bridge. Fifth Street Bridge [5FN1723], Fremont County, Colo. (Colorado Dept. of Transportation).

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Continuation Sheet

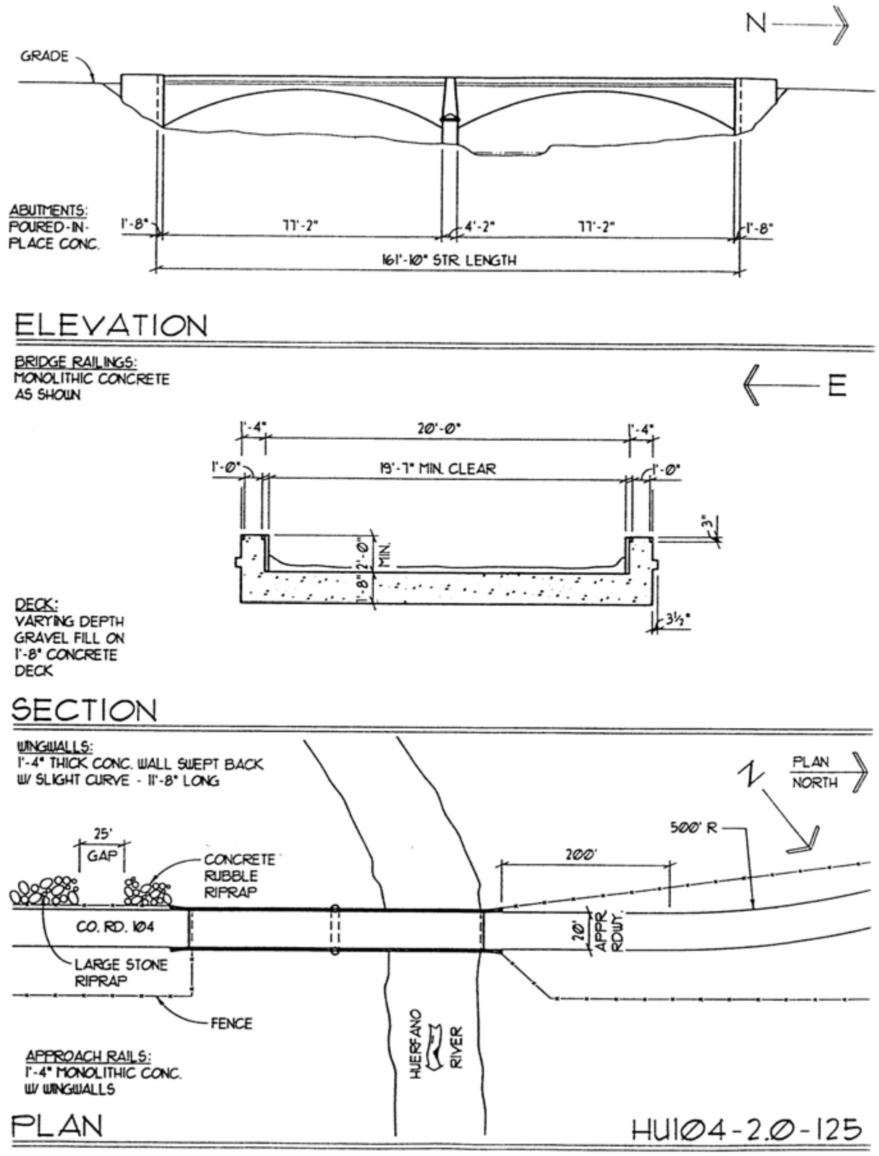

Figure 6. Example of Luten filled-spandrel concrete arch bridge. Butte Valley Bridge [5HF1907], Huerfano County, Colo. (Colorado Dept. of Transportation).

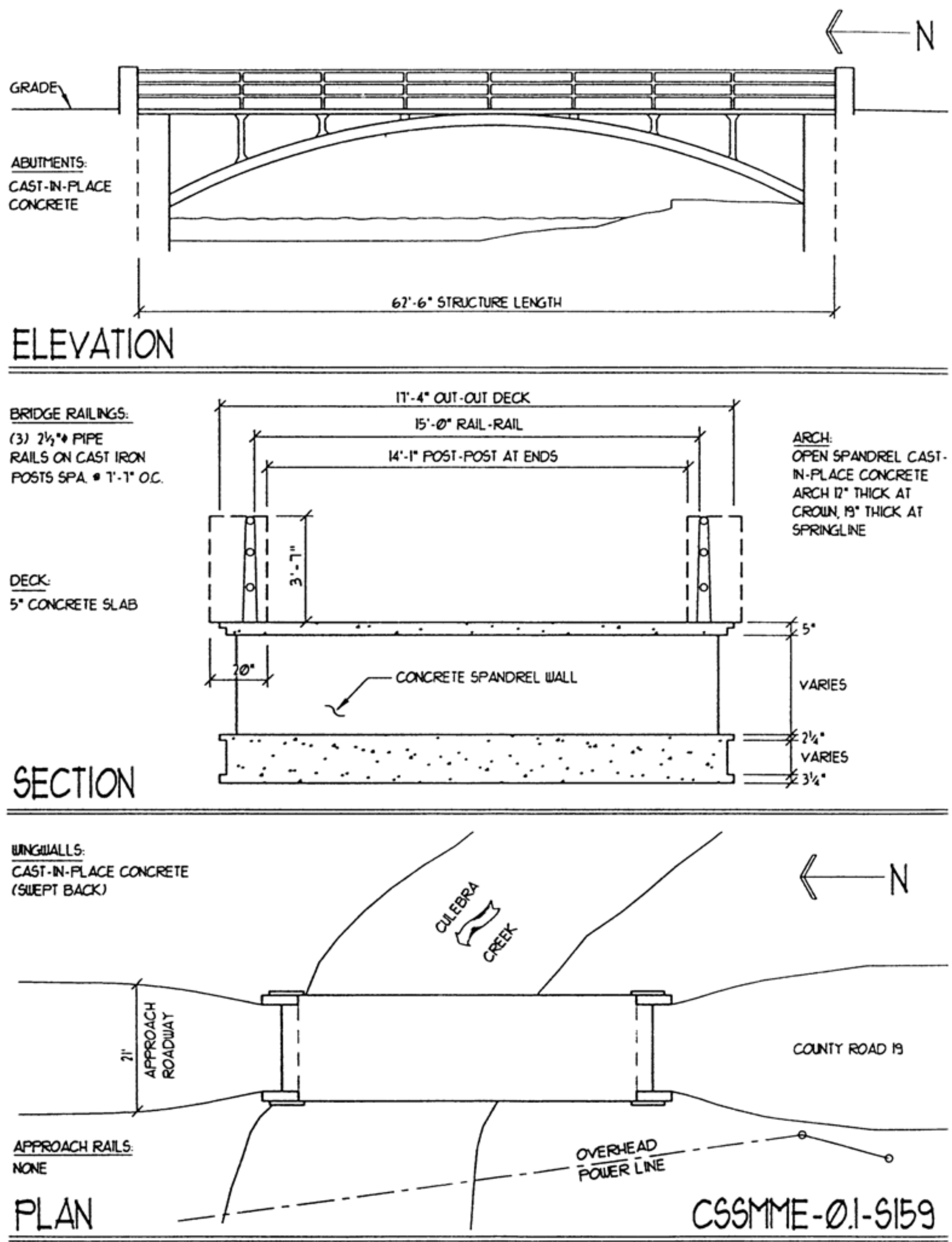

Figure 7. Example of open-spandrel concrete arch bridge. San Luis Bridge [5CT141], Costilla County, Colo. (Colorado Dept. of Transportation).

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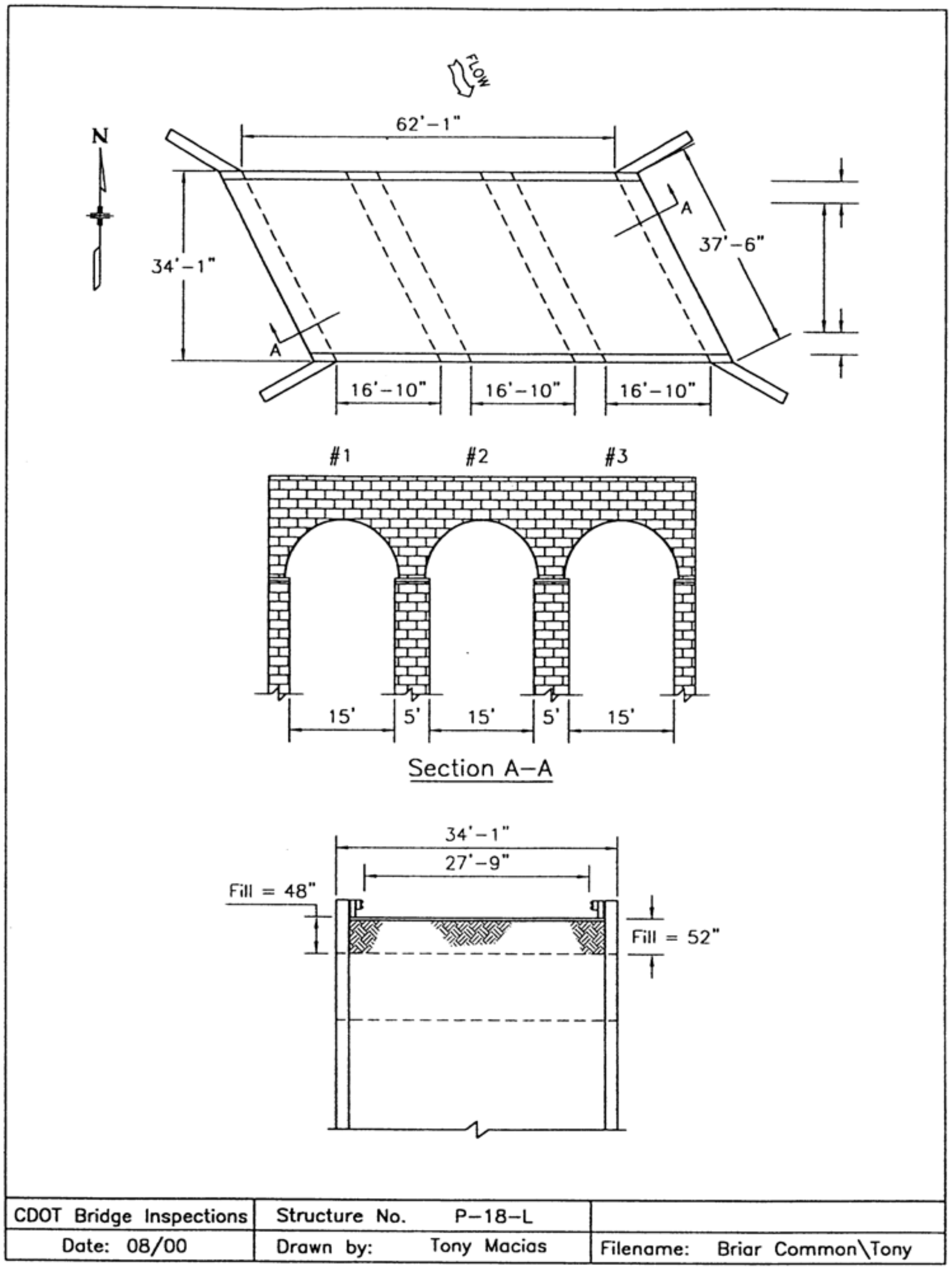

Figure 8. Example of stone arch bridge. Burro Canyon Bridge [5LA8115], Las Animas County, Colo. (Colorado Dept. of Transportation).

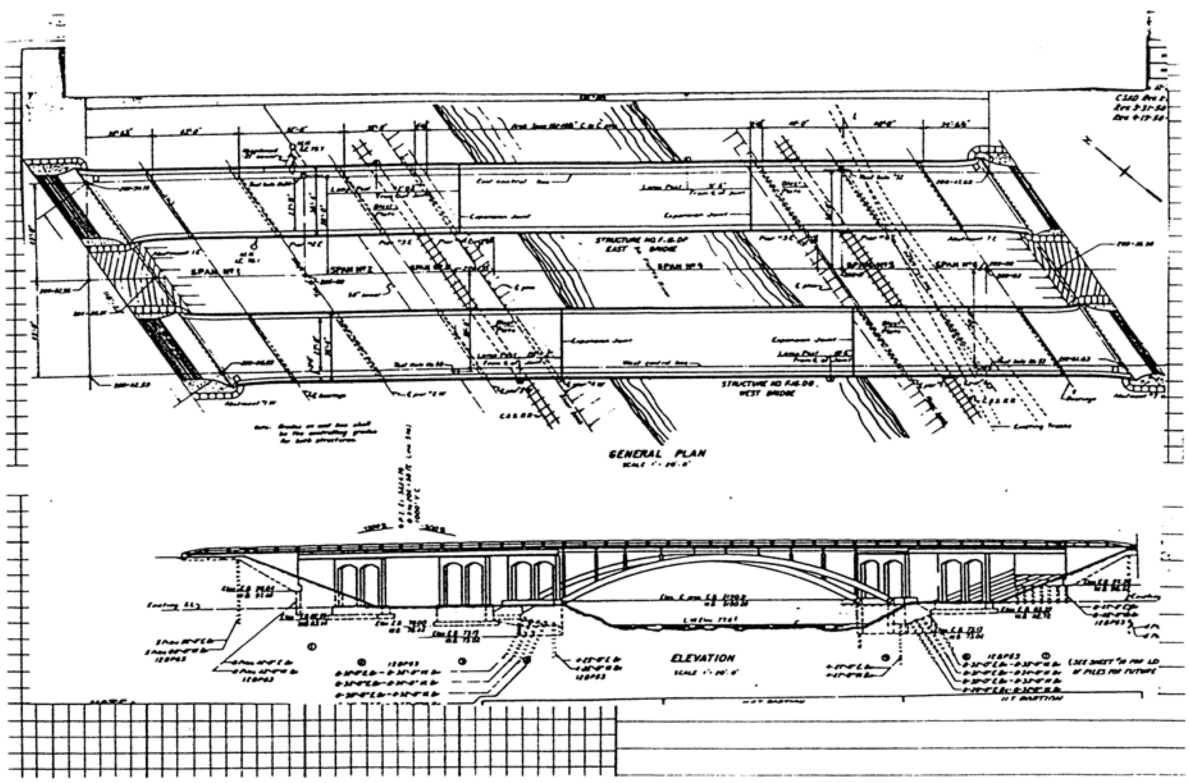

Figure 9. Example of steel arch bridge. South Platte River Bridge [5DV7072], Denver County, Colo. (Colorado Dept. of Transportation).

Significance: Concrete, stone and steel arch bridges in Colorado may be eligible for listing in the National Register of Historic Places under Criterion A for their association with events that have made a significant contribution to the broad historical patterns of the country, the state, or the region. Specifically, this includes those bridges that have played an important role in the development of the state's highway transportation system and, hence, in the settlement of the area. For example, a structure might be significant for its association with a particular route, such as the Omaha-Lincoln-Denver Highway, because it was built with assistance from the State Highway Commission in its formative years, or because it was built by a Federal Depression-era relief program. A bridge may, in addition, be eligible under Criterion B for its association with a significant person, as long as the "significant person" was not the designer or builder of the bridge. A bridge can be eligible by virtue of its designer or builder, but this falls under Criterion C. Indeed, most eligible bridges in Colorado qualify under Criterion C as structures of engineering significance. This can encompass a broad range of considerations. For instance, a bridge can qualify under Criterion C as a well-preserved example of a common type, or as an important variation.

Registration Requirements: The period of significance for concrete, stone and steel arch bridges in Colorado begins in 1900, the approximate date for the state's earliest examples of these structural types. The period of significance ends in 1951, the fifty-year date after which bridges must possess exceptional significance. Alterations made during the period of significance are considered part of the bridge's historic fabric. Such changes may or may not be in keeping with the bridge's original design. Integrity of the structure's historic materials and design is essential for the bridge to qualify for the National Register under any criterion. Since arch bridges are rarely moved, integrity of location is a given. Arch bridges may be eligible for the National Register under Criterion B for their association with a significant person, but this is rare. Most often, these bridges will have significance under Criteria A or C.

Specific requirements under Criterion A:

1. Early and/or prominent product of the Colorado State Engineer's Office or Colorado Highway Department:
In 1881 the Colorado State Legislature established the State Engineer's Office and funded specific bridge construction projects under the Internal Income Fund. Some of the later bridges built under this program were concrete arch structures, and one is known to remain today. In 1910 the state legislature formed the Colorado Highway Commission (and its successor, the Colorado Highway Department). Several concrete arches were designed by Highway Department in the 1920s and 1930s, and a few remain in place today.

2. Outstanding example of product of a Federal work relief program of the Depression era:
Federal work programs in the 1930s and early 1940s, particularly those funded by the Works Progress Administration, led to construction of a number of stone and multi-plate arch bridges in the state. The most significant display careful craftsmanship and creative design.

3. Association with a significant route or event (regional or statewide):
If the construction of or improvements to a route or highway helped open up a region for travel and commerce, or contributed to increased development and prosperity in nearby communities, the route or highway might be considered eligible under Criterion A. The bridges along this route, if unaltered from the period of significance, may also be eligible under Criterion A for their association with significant events. Similarly, if a bridge was built as part of a significant event, such as when the State Highway Department launched a campaign to improve the safety of bridge crossings over railroad features, it may be eligible under Criterion A for its association with that specific campaign.

4. Association with civic improvement projects, such as the City Beautiful movement:
Bridges built as part of a specific aesthetic or planning initiative in a community might be considered significant under Criterion A as local expressions of a national movement.

Specific requirements under Criterion C:

1. Early and/or representative concrete, stone, or steel arch bridge:
Although they are generally considered among the highest forms of bridge design, concrete and stone arches were never built in abundance in Colorado, and only a handful of steel highway bridges are known to have been erected. Those arch bridges with spans in excess of 30 feet (i.e., true bridges and not arch culverts) that remain with a high degree of structural integrity are sufficiently rare and noteworthy that most are considered significant.

2. Representative example by an important engineer, architect, or firm:
Proprietary concrete arch designs, such as those developed by Daniel Luten and James Marsh, are considered significant aspects of bridge design of the early 20th century. Accordingly, bridges constructed using these designs are considered significant.

3. Bridge with exceptional aesthetic merit:
Most bridges built in the state are strictly utilitarian. Occasionally, however, a structure stands out by virtue of its design or because of the quality displayed in its construction. Highway Department standard-design concrete guardrail is not considered exceptional as a stand-alone feature, but can contribute to the overall significance of a bridge if it is an integral part of the original design. The interrelationship of a bridge and its site can also have aesthetic value as well, if the bridge demonstrates a significant engineering achievement due to topographical conditions or constraints.

Property Type: Concrete rigid frame bridges

Description: The first concrete rigid frame bridge in America was designed in 1922 by engineer Arthur G. Hayden for the park commission of Westchester County, New York. Comprised of a concrete beam superstructure tied rigidly to the abutments with steel reinforcing bars, rigid frame bridges differed materially from conventional simply supported spans. "A clear conception of a typical rigid frame concrete bridge may be obtained by first visualizing an ordinary simple span bridge supported by bearing on two abutments," a 1935 concrete manual stated. "If the bearing is replaced with concrete that continues monolithically from the abutments to the deck, the altered structure becomes a frame with rigid corners—a structure generally called a *rigid frame concrete bridge*." Because its construction was relatively labor-intensive, this bridge configuration became popular for Federal relief projects during the 1930s. Both picturesque and practical, the flat-arch design appealed to proponents of urban beautification, and rigid frames found widespread use in city parks and landscaped boulevards. By 1935 more than 300 rigid frames had been built in America, most in urban areas. Early rigid frame bridges were limited in span length, but by 1937 the Schmitz Park Bridge in Seattle featured a single 175-foot span.[12]

Concrete rigid frame bridges were well suited to urban applications with large traffic volumes and moderate span lengths, where rigidity under load was of prime importance. Their design could be easily changeable as well. Using a standard profile and reinforcing configuration, a series of bridges could be built over a fairly wide range of span lengths. They could be readily skewed to accommodate angled intersections. Their flat or slightly arched undersides provided adequate under-bridge clearance. And they could be subsequently widened to accommodate increased traffic. Further, the bridges could be cast plainly or adorned with a variety of applied concrete or metal ornamentation.

The City of Denver was the first government entity known to construct rigid frame bridges in Colorado, with a few two-span structures over Cherry Creek built in the 1920s. In the late 1930s the Colorado Highway Department experimented with rigid frame design, building relatively small-scale structures at rural locations around the state. The first concerted use of rigid frame overpasses occurred in 1944, with the design of the Valley Highway through Denver by consulting engineers Crocker and Ryan. Built in the 1950s, the Valley Highway employed numerous two-span rigid frame structures at the grade separations with city streets. Despite the suitability of rigid frame structures for urban use, they were built only sparingly elsewhere in the state.

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[12] *Analysis of Rigid Frame Concrete Bridges* (Chicago: Portland Cement Association, 1935), 5; A.L. Cerveny, A.L. "Rigid Frame Bridges." *University of Colorado Highway Conference.* March 1939, 33-34.

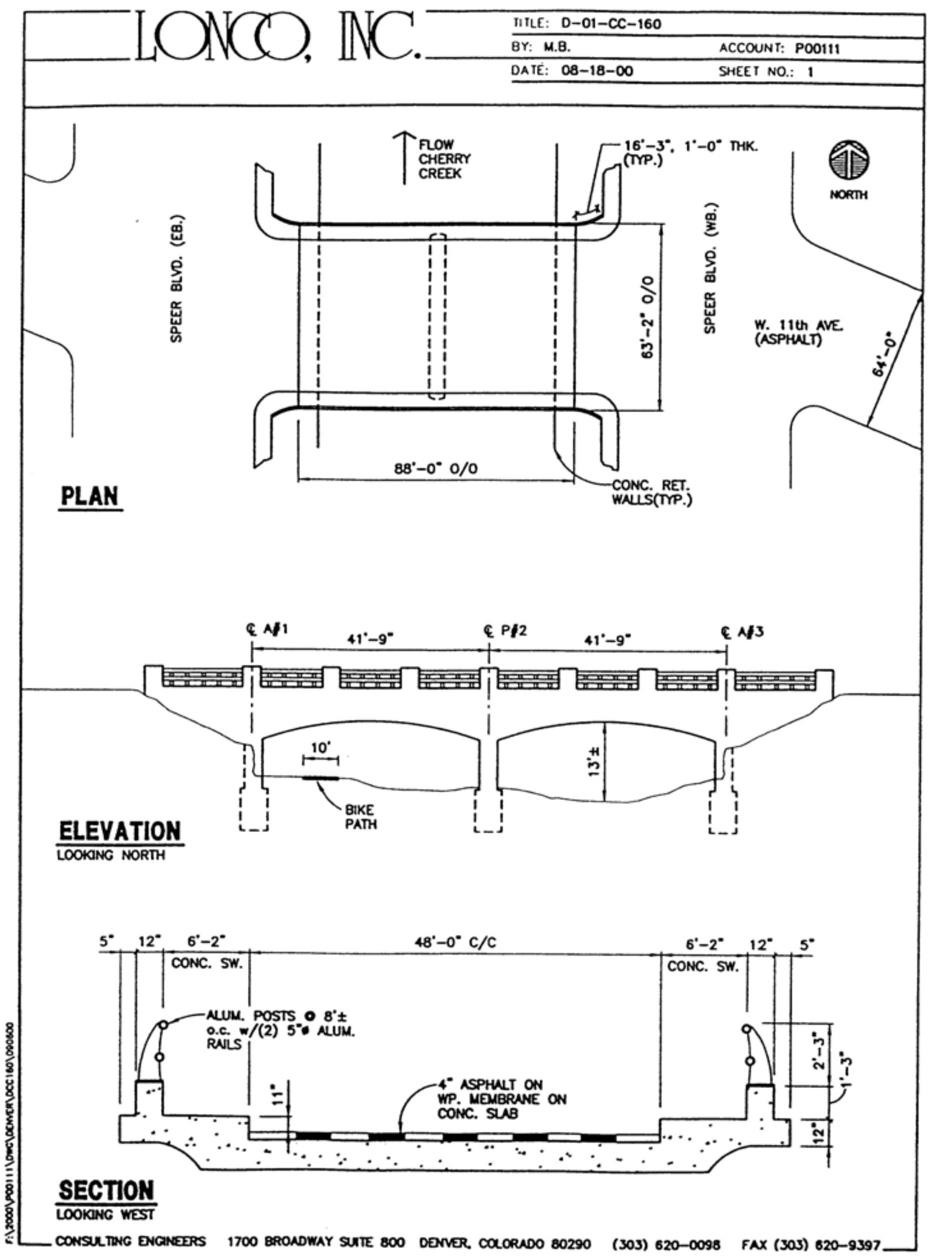

Figure 10. Example of concrete rigid frame bridge. Eleventh Avenue Bridge [5DV7096], Denver County, Colo. (Colorado Dept. of Transportation).

Significance: Concrete rigid frame bridges in Colorado may be eligible for listing in the National Register of Historic Places under Criterion A for their association with events that have made a significant contribution to the broad historical patterns of the country, the state, or the region. Specifically, this includes those bridges that have played an important role in the development of the state highway transportation system and, hence, in the settlement of the area. For example, a structure might be significant for its association with a particular route, such as the Valley Highway. A bridge may, in addition, be eligible under Criterion B for its association with a significant person, as long as the "significant person" was not the designer or builder of the bridge. A bridge can be eligible by virtue of its designer or builder, but this falls under Criterion C. Indeed, most eligible bridges in Colorado qualify under Criterion C as structures of engineering significance. This can encompass a broad range of considerations. For instance, a bridge can qualify under Criterion C as a well-preserved example of a common type, or as an important variation.

Concrete rigid frame bridges are sufficiently common in Colorado that to be considered eligible for listing in the National Register under Criterion C, a structure from this property type must have some superlative feature about it that distinguishes it from its peers. Some examples of this are notably early construction date, exceptionally long span length, unusually high span number, or well-executed architectural design.

Registration Requirements: The period of significance for concrete rigid frame bridges in Colorado begins in 1925, the construction date for the state's earliest examples of this structural type. The period of significance ends in 1952, the fifty-year date after which bridges must possess exceptional significance. Alterations made during the period of significance are considered part of the bridge's historic fabric. Such changes may or may not be in keeping with the bridge's original design. Integrity of the structure's historic materials and design is essential for the bridge to qualify for the National Register under any criterion. Since concrete rigid frame bridges cannot be moved, integrity of location is a given. Rigid frame bridges may be eligible for the National Register under Criterion B for their association with a significant person, but this is rare. Most often, these bridges will have significance under Criteria A or C.

Specific requirements under Criterion A:

1. Early and/or prominent product of the Colorado Highway Department:
In the 1930s the Highway Department began using concrete rigid frames for bridges and grade separations. Several remain in place today.

2. Association with a significant route or event (regional or statewide):
If the construction of or improvements to a route or highway helped open up a region for travel and commerce, or contributed to increased development and prosperity in nearby communities, the route or highway might be considered eligible under Criterion A. The bridges along this route, if unaltered from the period of significance, may also be eligible under Criterion A for their association with significant events. Similarly, if a bridge was built as part of a significant event, such as when the State Highway Department launched a campaign to improve the safety of bridge crossings over railroad features, it may be eligible under Criterion A for its association with that specific campaign.

3. Association with civic improvement projects, such as the City Beautiful movement:
Bridges built as part of a specific aesthetic or planning initiative in a community might be considered significant under Criterion A as local expressions of a national movement.

Specific requirements under Criterion C:

1. Early and/or representative concrete rigid frame bridges:
Concrete rigid frame bridges are considered significant if they can be definitively documented and they exhibit superlative features (i.e., exceptionally long span length, unusual number of spans, uncommonly good state of preservation).

2. Bridge with exceptional aesthetic merit:
Most bridges built in the state are strictly utilitarian. Occasionally, however, a structure stands out by virtue of its design or because of the quality displayed in its construction. Highway Department standard-design concrete guardrail is not considered exceptional as a stand-alone feature, but can contribute to the overall significance of a bridge if it is an integral part of the original design. The interrelationship of a bridge and its site can also have aesthetic value as well, if the bridge demonstrates a significant engineering achievement due to topographical conditions or constraints.

Property Type: Steel stringer and girder bridges

Description: Steel stringer bridges are the most rudimentary type of all-metal spans. Comprised of parallel rows of relatively shallow, rolled I-beams laid over piers and abutments, steel stringer bridges were used in abundance by Colorado railroads in the late 19th and early 20th centuries. Their spans were generally limited to less than 30 feet; beyond that the railroads typically employed riveted plate girder spans. Steel stringers began to replace short-span trusses for county roadway use in Colorado after the turn of the 20th century. Although they were routinely built, few of these earliest I-beam spans remain in place in the state. The decks for these early stringer structures typically featured timber planks or concrete slabs, although a modified concrete deck, poured over steel arch forms called "jack arches", was sometimes employed. Substructures for steel stringer bridges ran the gamut from stone masonry or concrete abutments to timber or steel pile bents. Like timber stringers, steel stringer bridges could consist of single-span structures over minor watercourses, or the spans could be multiplied over piers to cross rivers with wide flood plains. And like timber stringers, they could be designed and built using standard tables or empirical judgment, without the need for extensive engineering.

To assist the counties in building bridges on the newly formed state road system, the Colorado Highway Commission published its first design standards for steel stringer bridges in 1914. These early structures featured I-beam stringers with depths ranging from 12 to 24 inches, which could cover a range of spans between 16 and 36 feet.[13] The stringers were sheathed completely with concrete to protect them from weathering, giving the bridges an all-concrete appearance. The Highway Commission's sheathed stringer bridge proved unnecessarily expensive to build, however, and the concrete sheathing was soon eliminated, reducing the superstructure to its bare necessities. Since then steel beam bridges have enjoyed inconsistent popularity with Highway Department and county engineers, depending largely on the price of steel at the time. Steel shortages caused by World War I curtailed the use of stringer bridges during the 1910s. As prices fell in the 1920s, though, CHD resumed its reliance on rolled steel beams for bridge construction.

[13] Robert DuBois, "Standard I-Beam Bridges," *Colorado Highways Bulletin* 2:12 (December 1919), 6.

Perhaps more than any other bridge type, steel stringer technology has depended heavily on the capacity of rolling mills that provided the steel. Dependent upon the mills' output of shallow beams, early CHD stringer bridges were limited to spans shorter than 50 feet. It was necessary, therefore, to use other structural types such as steel plate girders, trusses, or concrete arches for crossings requiring greater spans. The Highway Department was able to increase these spans to 75 feet when the mills began to roll 33- to 36-inch-deep beams in 1928. The longer spans made steel bridges more economical than concrete, hence greatly increasing the number of long-span steel beam bridges built in Colorado in the 1930s. Even more than timber stringer or concrete girder bridges, steel stringer structures were flexible in span length, span number, roadway width, and substructure configuration. They could be built with simply supported bearing conditions or with the beams extending continuously over the piers. Moreover, they could be subsequently widened simply by extending the piers and abutments to the sides and adding more stringers outside of the original ones. So suitable were steel stringers to widening that they have often been used to widen the decks on other structural types such as concrete arches and slabs. As a result of this flexibility and economy, steel stringer bridges received widespread acceptance on Colorado highways in the 1920s, 1930s, and 1940s. The trend has continued to the present. Built in profusion by the Highway Department, by the cities, and by the counties, steel stringers today represent by far the most populous structural type among Colorado's highway bridges.

Steel girders employ a technology similar to that of stringers, substituting two or more deep-profile beams for the row of relatively shallow stringers. Like concrete girder structures, they could be configured with several beams located beneath the roadway (called deck girders) or two relatively deep beams on both sides of the roadway (through girders). With their more complicated bearing condition, beam arrangement, and floor system connections, steel girder bridges mark a step up the technological scale from stringers. It was this increased technology—along with relatively heavy superstructural weight and the physical limitation of transporting heavy, factory-fabricated girders—that limited the application of steel girders for highway use in America in the early 20th century. Railroads were well-suited for girder construction, however, because they constituted their own transportation system capable of carrying large, heavy loads. As a result, virtually all of Colorado's early girder bridges started out as railroad structures. These were later converted to highway use, either by using the bridge in place or by salvaging the girders and moving them to different locations.

During the 1920s and 1930s the Highway Department began building its own steel deck girder structures. These were detailed similarly to their railroad-designed predecessors, typically with two deep steel plates, each of which featured steel angle flanges and web stiffeners riveted in place. CHD engineers preferred steel trusses to deck girders for long spans and concrete girders or steel stringers for short spans. As a result, girders were not built in abundance around the state. Those that remain tend to be from highway construction of the late 1940s and 1950s.

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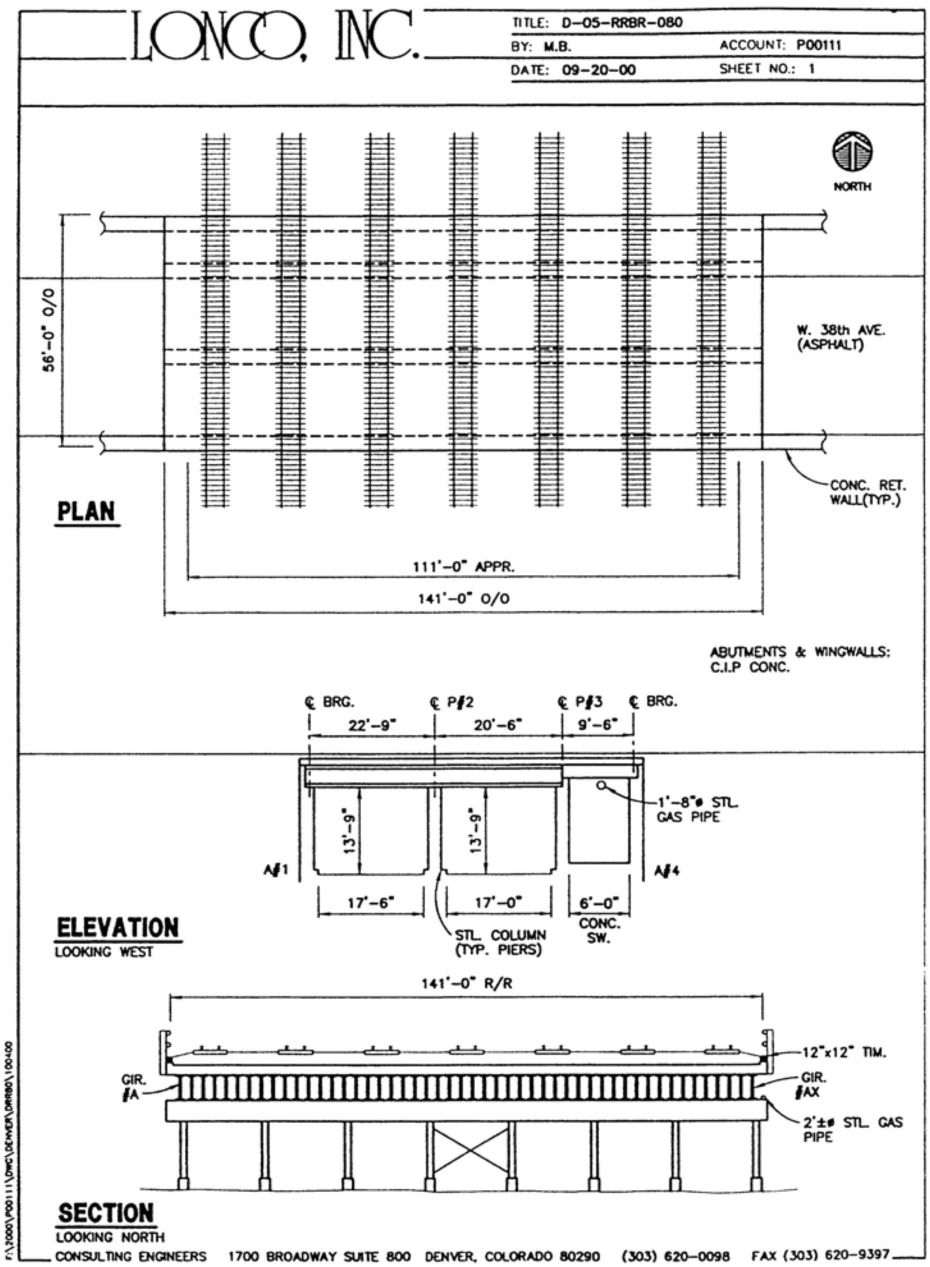

Figure 11. Example of steel stringer bridge. 38th Street Bridge [5DC7110], Denver County, Colo. (Colorado Dept. of Transportation).

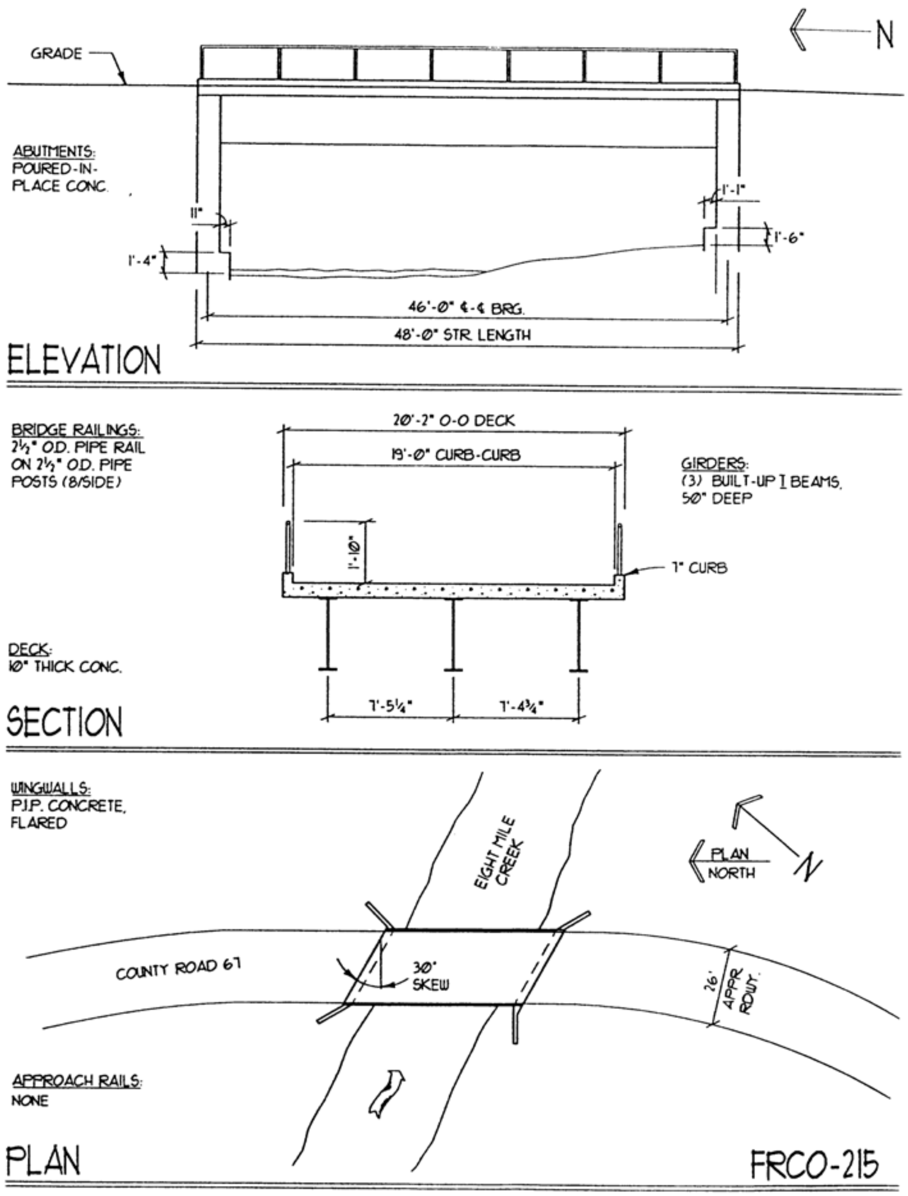

Figure 12. Example of steel girder bridge. Eight Mile Creek Bridge [5FN1701], Fremont County, Colo. (Colorado Dept. of Transportation).

Significance: Steel stringer or girder bridges in Colorado may be eligible for listing in the National Register of Historic Places under Criterion A for their association with events that have made a significant contribution to the broad historical patterns of the country, the state, or the region. Specifically, this includes those bridges that have played an important role in the development of the state's highway transportation system and, hence, in the settlement of the area. For example, a structure might be significant for its association with a particular route, such as the Ocean-to-Ocean Highway, because it was built with assistance from the State Highway Commission in its formative years, or because it was built by a Federal Depression-era relief program. A bridge may, in addition, be eligible under Criterion B for its association with a significant person, as long as the "significant person" was not the designer or builder of the bridge. A bridge can be eligible by virtue of its designer or builder, but this falls under Criterion C. Indeed, most eligible bridges in Colorado qualify under Criterion C as structures of engineering significance. This can encompass a broad range of considerations. For instance, a bridge can qualify under Criterion C as a well-preserved example of a common type, or as an important variation.

Steel stringer and girder bridges are sufficiently common in Colorado that to be considered eligible for listing in the National Register under Criterion C, a structure from this property type must have definitive historical documentation and some superlative feature that distinguishes it from its peers. Some examples of this are notably early construction date, exceptionally long span length, unusually high span number, or well-executed architectural design.

Registration Requirements: The period of significance for steel stringer and girder bridges in Colorado begins in 1880, the approximate date for the state's earliest examples of these structural types. The period of significance ends in 1952, the fifty-year date after which bridges must possess exceptional significance. Alterations made during the period of significance are considered part of the bridge's historic fabric. Such changes may or may not be in keeping with the bridge's original design. Integrity of the structure's historic materials and design is essential for the bridge to qualify for the National Register under any criterion. Stringer and girder bridges may be eligible for the National Register under Criterion B for their association with a significant person, but this is rare. Most often, these bridges will have significance under Criteria A or C.

Specific requirements under Criterion A:

1. Early and/or prominent product of the Colorado State Engineer's Office or Colorado Highway Department:
In 1881 the Colorado State Legislature established the State Engineer's Office and funded specific bridge construction projects under the Internal Income Fund. Some of the later bridges built under this program were steel beam structures. In 1910 the state legislature formed the Colorado Highway Commission (and its successor, the Colorado Highway Department). Numerous steel stringer and girder bridges were designed by the Highway Commission in the 1910s and early 1920s, and a few remain in place today.

2. Outstanding example of product of a Federal work relief program of the Depression era:
Federal work programs in the 1930s and early 1940s, particularly those funded by the Works Progress Administration, led to construction of a number of steel beam bridges in the state. The most significant display careful craftsmanship and creative design.

3. Association with a significant route or event (regional or statewide):
If the construction of or improvements to a route or highway helped open up a region for travel and commerce, or contributed to increased development and prosperity in nearby communities, the route or highway might be considered

eligible under Criterion A. The bridges along this route, if unaltered from the period of significance, may also be eligible under Criterion A for their association with significant events. Similarly, if a bridge was built as part of a significant event, such as when the State Highway Department launched a campaign to improve the safety of bridge crossings over railroad features, it may be eligible under Criterion A for its association with that specific campaign.

4. Association with civic improvement projects, such as the City Beautiful movement:
Bridges built as part of a specific aesthetic or planning initiative in a community might be considered significant under Criterion A as local expressions of a national movement.

Specific requirements under Criterion C:

1. Early and/or representative steel stringer and girder bridges:
Steel beam bridges built before 1920 are sufficiently rare in Colorado that any example that has retained structural integrity is considered significant. Those built after 1920 with definitive documentation are considered significant on the basis of superlative features (i.e., exceptionally long span length, unusual number of spans, uncommon state of preservation). Steel beam bridges built after 1951 are considered exceptionally significant if they were prototypes for their respective structural configuration.

2. Bridge with exceptional aesthetic merit:
Most bridges built in the state are strictly utilitarian. Occasionally, however, a structure stands out by virtue of its design or because of the quality displayed in its construction. The interrelationship of a bridge and its site can also have aesthetic value as well, if the bridge demonstrates a significant engineering achievement due to topographical conditions or constraints.

Property Type: Iron and steel truss bridges

Description: Beginning in the late 1870s, the pin-connected wrought iron truss was the roadway bridge of choice for medium- and long-span crossings in America. Made up of numerous built-up metal members connected to form series of triangles in a variety of web configurations, trusses functioned as complex, long-span beams. They carried traffic in three positions: the through configuration, with the roadway positioned between two tall webs and overhead struts spanning between the webs; the pony configuration, with the roadway positioned between two relatively short webs, without overhead struts; and the deck configuration, with the roadway carried completely on top of the truss webs. In the 19th century trusses underwent an evolution of form that reflected other technological advancements. For instance, cylindrical pins were first used to connect metal truss members in 1859. Two years later, a complementary truss member—the forged iron eyebar—was introduced. Steel eyebars appeared in the 1870s. Production of Bessemer and open-hearth steel improved in both quality and economy in the 1880s, and by 1890 all-steel bridges had largely superseded wrought iron structures.

Trusses were typically fabricated by manufacturers in large-scale shops, purchased by government entities through competitive bidding, shipped in pieces to the bridge sites, and assembled over temporary wooden falsework. The bridge companies that proliferated through the Midwest and Ohio River Valley competed enthusiastically for county bridge business, marketing an ever-changing array of truss types through networks of regional sales representatives. Both patented in the 1840s, the Pratt and Warren web configurations—with their various subtypes—formed the basis for the overwhelming majority of all-metal trusses built in Colorado in the late 19th and early 20th centuries. These structures were fabricated by such national firms as the King Iron Bridge Company and the Wrought Iron Bridge Company of Ohio, and such regional firms as the Midland Bridge Company of Kansas City, the Missouri Valley Bridge and Iron Works of Leavenworth, Kansas, and the Bullen Bridge Company and Denver Bridge Company of Colorado.

The earliest truss bridges featured pinned and bolted connections in some combination. These were largely superseded by all-pinned trusses in the 1880s. Because of their relatively quick erection and easy fabrication, pin-connected trusses dominated the market until well into the 20th century. But they lacked rigidity and could loosen from vibrations caused by traffic and the wind. Rigid connections in trusses, with stiffening gusset plates at the joints, created stronger, sturdier connections, but field riveting was not practical before portable pneumatic riveters became available after the turn of the century. In Colorado rigid-connected trusses began to overshadow pinned for highway spans around 1910.

Without question the most popular truss type of the period was the Pratt truss. 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 functioned in tension. Its parallel chords and equal panel lengths resulted in standardized sizes for the verticals, diagonals, and chord members, making fabrication and assembly relatively easy. "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 his influential *Bridge Engineering*. "Its advantages are simplicity, economy of metal, and suitability for connecting to the floor and lateral systems."[14]

In the highly competitive bridge manufacturing industry, in which efficiency equated with profit, Pratt trusses received almost universal use. Virtually all of the major regional fabricators manufactured Pratt trusses and marketed them extensively to Colorado's counties in the late 19th and early 20th centuries. As a result, the Pratt truss was the

[14] J.A.L. Waddell, *Bridge Engineering* (London: John Wiley and Sons, 1916), 468.

structure of choice in the state for medium- and long-span wagon bridges. More Pratt trusses were built in Colorado during the period than all other truss types combined.

From the straight-chorded Pratt design arose a variety of structural subtypes in the 19th century. Another Pratt sub-type built in the 19th century was called the Pratt half-hip truss. The half-hip's 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. The most common Pratt subtype was the Parker truss. Developed in the 19th century by C.H. Parker, the Parker truss was characterized by upper chords and vertical members that acted in compression and lower chords and diagonals acting in tension. 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 his book, stating: "[The Pratt's] chords are not necessarily parallel, but may be inclined. This latter form is frequently known as the Parker truss." [15]

The inclined upper chords of the Parker afforded a degree of efficiency on long-span trusses, where bending stresses at mid-span greatly exceed the shear stresses at the ends. As literal manifestations of stress analysis, polygonal-chorded trusses placed the heaviest amount of metal at the point where the stresses were the greatest: in the middle. 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 and erection costs somewhat. Because trusses were generally priced on the basis of their superstructural steel weight, the lighter overall weight of a polygonal-chord truss more than offset the slight increase in fabricating costs in spans greater than 150 feet.

A Camelback truss is a Parker with exactly five facets in its upper chord. With its distinctive profile, the Camelback configuration was disdained by many engineers for its ungainly appearance and its tendency under certain conditions to reverse compressive and tensile forces acting on individual members. As a result, Camelback trusses never received widespread acceptance in the 19th and early 20th centuries. The Whipple truss resembles the Pratt in its array of compression and tension members. Its primary difference lies in its diagonals, which extend over two panels. Patented in 1847 by esteemed civil engineer Squire Whipple, this eponymous 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. As the Whipple represents a sub-divided Pratt, the Pennsylvania truss is a subdivided Parker.

In Colorado, the Pratt and its various modified designs rode a wave of popularity well into the 20th century. The other principal truss category that competed with the Pratt in the late 19th and early 20th centuries was the Warren truss. Patented in 1848 by Captain James Warren and Theobald Monzani, the Warren truss in its classic form features a web configuration that relies on simple triangulation for its rigidity. Warrens were built sparingly in the 19th century, a period in which the pin-connected Pratt dominated the bridge industry. After about 1910, however, rigid-connected Warren pony trusses began to compete with earlier Pratt configurations for use on short- to intermediate-span highway bridges. Although these bridges displayed variations in their web configurations (some were "pure" Warrens without verticals, others had verticals at all or alternating panel points), virtually all of these early Warrens featured straight upper chords.

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[15] Waddell, *Bridge Engineering*, 469.

United States Department of the Interior
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Continuation Sheet

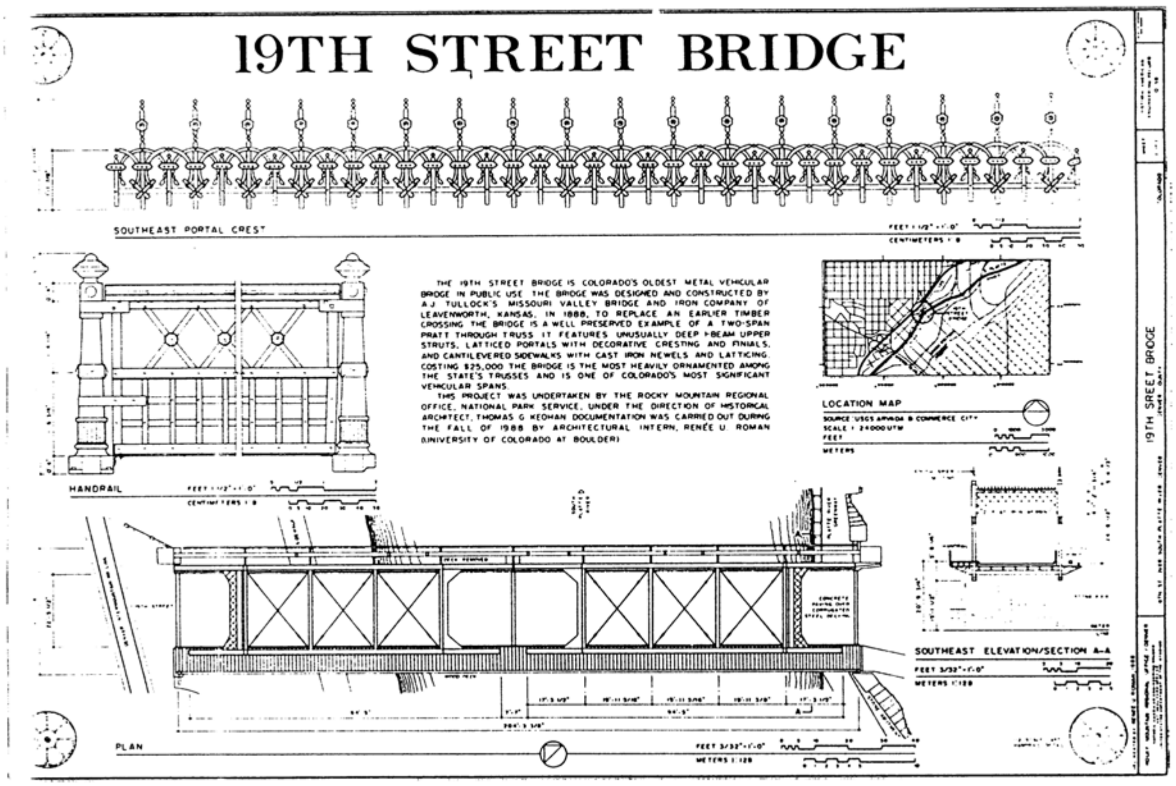


Figure 13. Example of steel through truss bridge. Nineteenth Street Bridge [5DV535], Denver County, Colo. (Historic American Engineering Record, National Park Service).

Colorado's counties erected a typical array of truss types but concentrated primarily on the Pratt and its subtypes in the late 19th and early 20th centuries. The earliest Pratts featured pinned connections in what was known as the "American style" of truss assembly. Concurrent with the development of more portable riveting equipment, the switch from pinned connections to the inherently stronger riveted connections for vehicular trusses occurred after 1910. The Colorado State Engineer's office preferred straight-chorded trusses to polygonal-chorded trusses in the late 19th and early 20th centuries, largely because the majority of bridges it was building did not require particularly long spans. There were noteworthy exceptions to this, however. Among the first polygonal-chorded trusses built by the state was the single-span structure over the Colorado River at Silt, completed in 1908. Comprised of a pin-connected Pennsylvania truss, its 252-foot span ranked among the longest of Colorado's wagon bridges. Other, shorter spans followed, and as late as 1919 the state was still erecting pin-connected Parker trusses at its long-span crossings.[16]

[16] *Fourteenth Biennial Report of the State Engineer to the Governor of Colorado* 1907-1908 (Denver: Smith-Brooks Printing Company, 1909), 105-106.

Around 1920 the State Highway Commission formulated its first standard plans for rigid-connected trusses, with the design for a short-span Pratt pony truss. When it formulated its standards for longer rigid-connected trusses in the early 1920s, the Highway Department adopted the straight-chorded Pratt for through truss spans between 100 and 140 feet and the polygonal-chorded Parker for longer spans. Among the first Parker through trusses built from CHD standard plans were the single-span structure over the Rio Grande River near Monte Vista; the Las Animas Bridge, a five-span structure over the Arkansas River; and the Buttes Bridge, a two-span structure over Fountain Creek in El Paso County. Erected in 1922-1923, these bridges all used eight-panel, 150-foot trusses, with only minor variations in their portal struts and web members.[17]

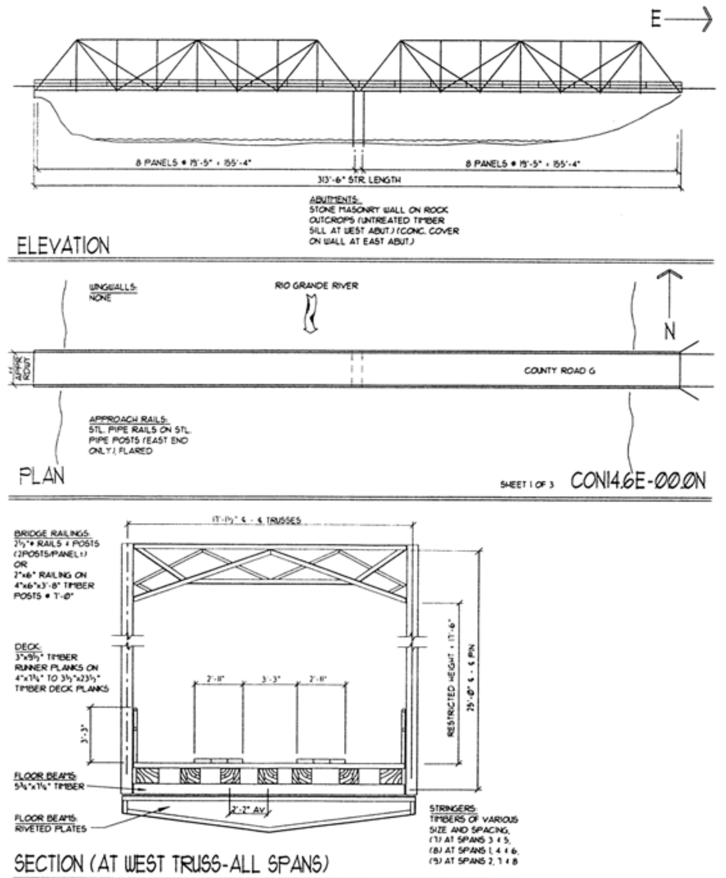


Figure 14. Example of steel through truss bridge. Costilla Crossing Bridge [5CN909], Conejos County, Colo. (Colorado Dept. of Transportation).

[17] "Improved Roads Help Farmers," *Colorado Highways* 1:4 (July 1922): 9; John S. Means, "Road Construction of Different Types During Recent Years," *Colorado Highways* 1:6 (September 1922): 6; R.S. Du Bois, "Las Animas Bridge Open to Travel," *Colorado Highways* 1:9 (December 1922): 3, 16; R.S. Du Bois, "Buttes Bridge Open to Traffic," *Colorado Highways* 2:2 (February 1923): 7.

The Highway Department experimented briefly with the Parker configuration for long-span pony trusses, building a limited number of these spans in the mid-1920s before settling on the Camelback as its long-span pony truss standard. Rigid connections, which eliminated its negative structural proclivities, made the Camelback more palatable for highway engineers of the 1920s. The Colorado Highway Department and its predecessors had been using Pratts and their sub-types since the 1880s, and the Camelback was a logical choice for its standard long-span pony truss. CHD delineated Camelback ponies in 80-foot, 100-foot, and 125-foot span lengths, with a range of roadway widths, and built hundreds of them around the state during the 1920s, 1930s, and 1940s. Most of these were single-span iterations, but CHD also constructed Camelbacks in groups of two or more trusses. More than any other structural type, steel trusses have suffered a terrible attrition through subsequent bridge replacements. Today only a small number remains from the thousands of trusses that once stood in the state.

Significance: Iron and steel truss bridges in Colorado may be eligible for listing in the National Register of Historic Places under Criterion A for their association with events that have made a significant contribution to the broad historical patterns of the country, the state, or the region. Specifically, this includes those bridges that have played an important role in the development of the state's highway transportation system and, hence, in the settlement of the area. For example, a structure might be significant for its association with a particular route, such as the Midland Trail, because it was built with assistance from the State Highway Commission in its formative years, or because it was built by a Federal Depression-era relief program. A bridge may, in addition, be eligible under Criterion B for its association with a significant person, as long as the "significant person" was not the designer or builder of the bridge. A bridge can be eligible by virtue of its designer or builder, but this falls under Criterion C. Indeed, most eligible bridges in Colorado qualify under Criterion C as structures of engineering significance. This can encompass a broad range of considerations. For instance, a bridge can qualify under Criterion C as a well-preserved example of a common type, or as an important variation.

Although their numbers are substantially diminished by attrition, metal trusses are still sufficiently common in Colorado that to be considered eligible for listing in the National Register, a structure from this property type must have definitive historical documentation.

Registration Requirements: The period of significance for iron and steel truss bridges in Colorado begins in 1880, the approximate date for the state's earliest examples of these structural types. The period of significance ends in 1952, the fifty-year date after which bridges must posses exceptional significance. Alterations made during the period of significance are considered part of the bridge's historic fabric. Such changes may or may not be in keeping with the bridge's original design. The definition of integrity may vary, however, depending on the criterion. Because location is of primary importance under Criterion A, a structure will rarely qualify under this criterion if it does not remain on its original site. Location can also have significance under Criterion B, but the correlation is not as universal. When focusing on engineering significance under Criterion C, the mobility of metal trusses is an important trait, since the structures were actually designed to be moved. Movement of the truss superstructure under this criterion might not necessarily detract from its historic integrity. On the other hand, structural integrity is of vital importance for those bridges considered under Criterion C. In engineering terms, a truss bridge is considered to be comprised of a group of distinct structural subsystems, rather than a single entity. These systems, in general order of importance under Criterion C, are the superstructure, the substructure, the floor, and the approach spans, if any. The super- and substructure of a bridge, for instance, may have retained a high degree of physical integrity, while the floor system and approach spans may have been altered, replaced, or even removed, and the bridge may still be considered eligible for registration. Loss of physical integrity may also be mitigated by technological significance for unique or rare structural types.

Specific requirements under Criterion A:

1. Early and/or prominent product of the Colorado State Engineer's Office or Colorado Highway Department:
In 1881 the Colorado State Legislature established the State Engineer's Office and funded specific bridge construction projects under the Internal Income Fund. Many of the bridges built under this program were steel truss structures. In 1910 the state legislature formed the Colorado Highway Commission (and its successor, the Colorado Highway Department). Numerous steel trusses were designed by the Highway Commission in the 1910s and 1920s, and a few remain in place today.

2. Outstanding example of product of a Federal work relief program of the Depression era:
Federal work programs in the 1930s and early 1940s, particularly those funded by the Works Progress Administration, led to construction of a number of steel beam bridges in the state. The most significant display careful craftsmanship and creative design.

3. Association with a significant route or event (regional or statewide):
If the construction of or improvements to a route or highway helped open up a region for travel and commerce, or contributed to increased development and prosperity in nearby communities, the route or highway might be considered eligible under Criterion A. The bridges along this route, if unaltered from the period of significance, may also be eligible under Criterion A for their association with significant events. Similarly, if a bridge was built as part of a significant event, such as when the State Highway Department launched a campaign to improve the safety of bridge crossings over railroad features, it may be eligible under Criterion A for its association with that specific campaign.

4. Association with civic improvement projects, such as the City Beautiful movement:
Bridges built as part of a specific aesthetic or planning initiative in a community might be considered significant under Criterion A as local expressions of a national movement.

Specific requirements under Criterion C:

1. Early and/or representative iron and steel truss bridges:
In the late 19th and early 20th centuries, metal truss bridges displayed a wide diversity of designs. This variety began to disappear by the 1910s, in part due to the influence of standard designs distributed by CHD. Since cast and wrought iron bridge members were virtually eliminated due to the availability of steel by the 1890s, these bridges are extremely rare and significant. Similarly, truss bridges built before 1910 are sufficiently rare that all documented examples that retain structural integrity are considered significant. Highway Department standard trusses—rendered rare by subsequent attrition—are also considered generally significant. The lone exception to this are Camelback pony trusses, which are sufficiently common that only superlative examples are considered significant.

2. Exceptional example of work by an important engineer, architect or firm:
This includes local, regional, and national companies and designers.

3. Bridge with exceptional aesthetic merit:
Most bridges built in the state are strictly utilitarian. Occasionally, however, a structure stands out by virtue of its design or because of the quality displayed in its construction. This does not include standard-design concrete guardrails by the Highway Department, however. The interrelationship of a bridge and its site can also have aesthetic value as well, if the bridge demonstrates a significant engineering achievement due to topographical conditions or constraints.

United States Department of the Interior
National Park Service

National Register of Historic Places Continuation Sheet

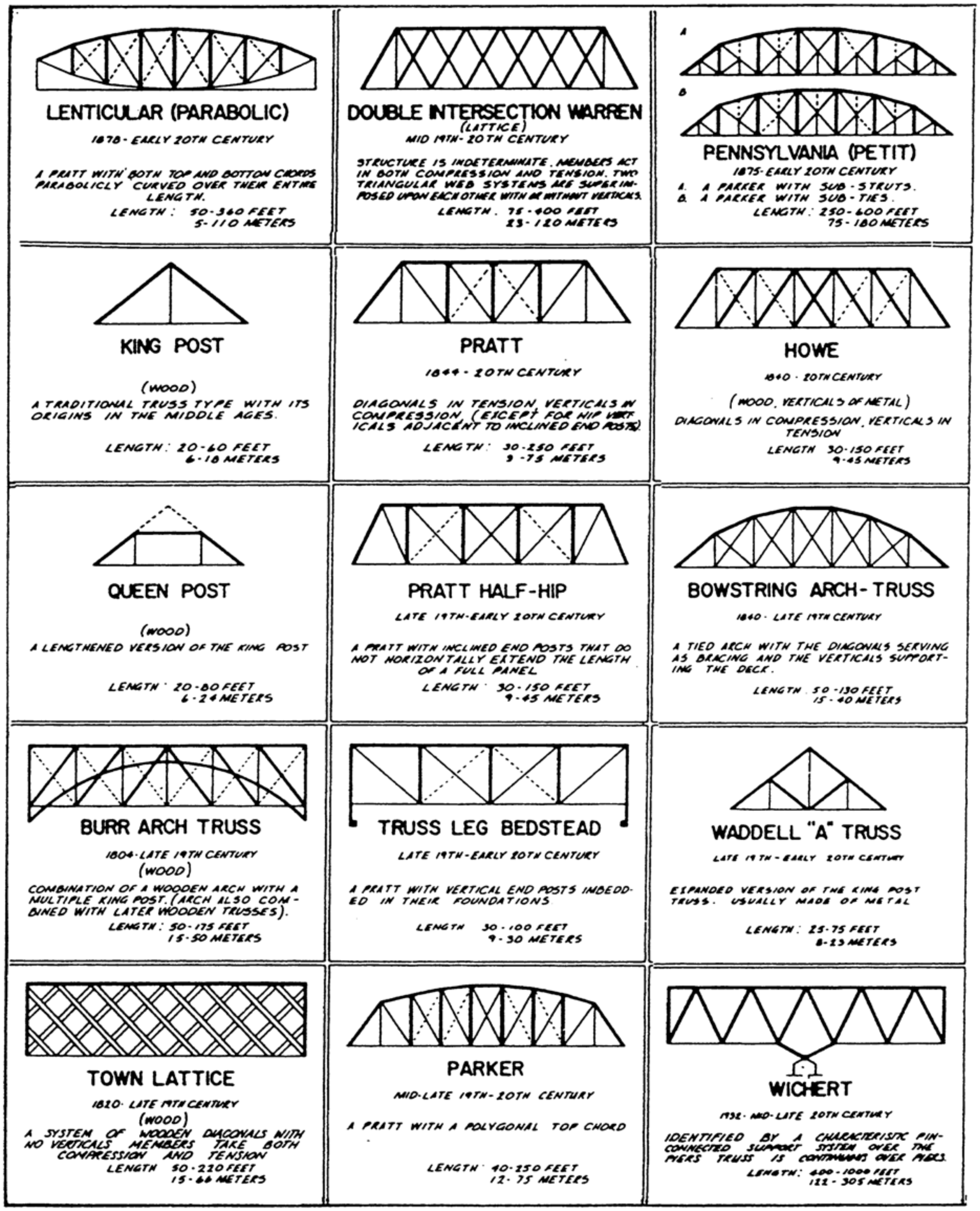


Figure 15. Truss bridge types, from poster produced by Historic American Engineering Record.

United States Department of the Interior
National Park Service

National Register of Historic Places
Continuation Sheet

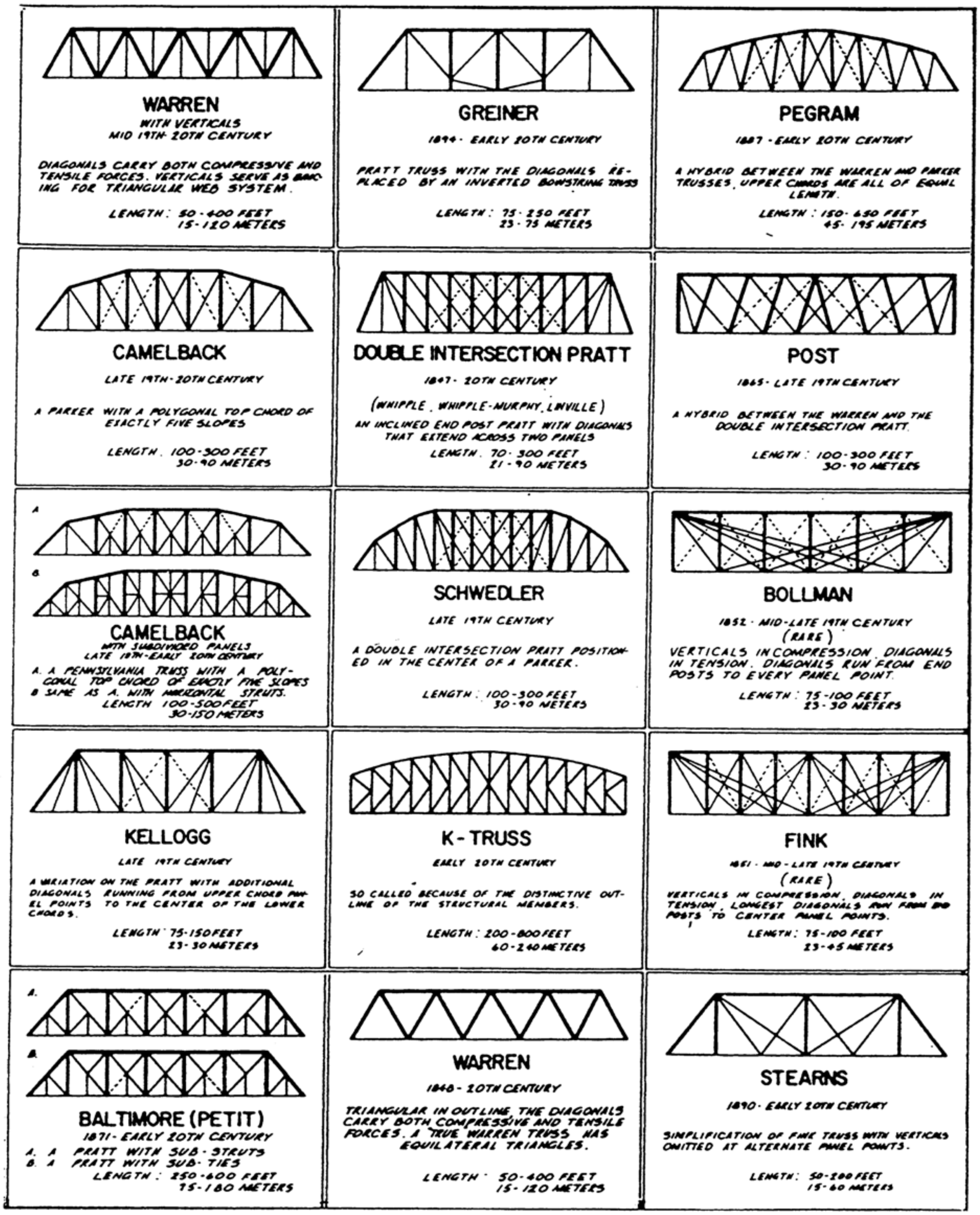


Figure 16. Truss bridge types, from poster produced by Historic American Engineering Record.

Glossary

This reference glossary contains numerous terms not included in the body of this document. Many of the definitions are from the Federal Highway Administration Bridge Inspector's Training Manual.

A

Abutment - A substructure supporting the end of a single span or the extreme end of a multi-span superstructure and, in general, retaining or supporting the approach embankment.

Alloy - A mixture of two or more metals to form a new base metal.

Anchorage - The complete assemblage of members and parts designed to hold in correct position the anchor span of a cantilever bridge, the end suspension span cable, or a suspension span backstay; the end of a restrained beam, girder, or truss span; a retaining wall, bulkhead, or other portion or part of a structure.

Anchor Span - The span that counterbalances and holds in equilibrium the fully cantilevered portion of an adjacent span; see Cantilever Beam, Girder, or Truss.

Angle - A rolled member of steel or iron forming an "L" shape.

Arch - A curved structural element primarily in compression, producing at its supports reactions having both vertical and horizontal components.

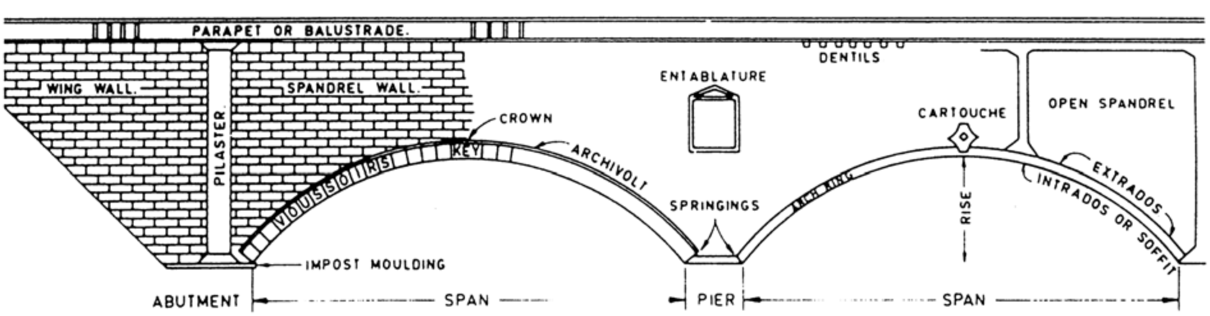


Figure 17. Terms used in arches. Taken from: *A Span of Bridges* (Newton Abbot, Great Britain: David and Charles Limited, 1970): 16.

Arch Barrel - A single arch member that extends the width of the structure.

Arch Rib - The main support element used in open - spandrel arch construction; also known as arch ring.

B

Backstay - Cable or chain attached at the top of a tower and extending to and secured upon the anchorage to resist overturning stresses exerted upon the tower by a suspended span.

Backwall - The topmost portion of an abutment above the elevation of the bridge seat, functioning primarily as a retaining wall with a live-load surcharge; it may serve also as a support for the extreme end of the bridge deck and the approach slab.

Batten - A narrow strip of metal used to fasten other pieces together in a built-up member.

Batter - The inclination of a surface in relation to a horizontal or a vertical plane, the angle is commonly designated on bridge detail plans as number of feet to 1 foot.

Beam - A linear structural member designed to span from one support to another.

Bearing - A support element transferring loads from superstructure to substructure, capable of permitting limited movement.

Bent - A substructure unit made up of two or more column or column-like members connected at their top most ends by a cap, strut, or other member holding them in their correct positions.

Box Beam - A hollow structural beam with a square, rectangular, or trapezoid cross section.

Bracing - A system of tension or compression members, or a combination of these, that maintains the geometric configuration of primary members. It transfers wind, dynamic, impact, and vibratory stresses and gives rigidity throughout the complete assembly.

Breastwall - The portion of an abutment between the wings and beneath the bridge seat; the breastwall supports the superstructure loads and retains the approach fill.

Bridge - A structure spanning and providing passage over a river, chasm, road, etc.

Built-Up - Forming a bridge member (such as a chord or a vertical) from smaller pieces (such as angles or channels) by riveting or welding them together.

Built-Up Member - A column or beam composed of plates and angles or other structural shapes united by bolting, riveting, or welding.

Bulkhead - A retaining wall-like structure commonly composed of driven piles supporting a wall or a barrier of wooden timbers or reinforced concrete members.

Buttress - A bracket-like wall, of full or partial height, projecting from another wall; the buttress strengthens and stiffens the wall against overturning forces; all parts of a buttress act in compression.

Buttressed Wall - A retaining wall designed with projecting buttresses to provide strength and stability.

C

Cable - A tension member comprised of numerous individual steel wires twisted and wrapped in such a fashion as to form a rope of steel; see *Suspension Bridge*.

Cable-Stayed Bridge - A bridge in which the superstructure is directly supported by cables or stays, passing over or attached to towers located at the main piers.

Camber - The slightly arched form or convex curvature provided in beams to compensate for dead-load deflection; in general, a structure built with perfectly straight lines appears slightly sagged.

Cantilever - A structural member which has a free end projecting beyond its supporting wall or column; length of span overhanging the support.

Cantilever Abutment - An abutment that resists the lateral thrust of earth pressure through the opposing cantilever action of a vertical stem and horizontal footing.

Cantilever Bridge - A general term applying to a bridge having a superstructure utilizing cantilever design.

Cantilever Span - A superstructure span composed of two cantilever arms, or a suspended span supported by one or two cantilever arms.

Cap - The topmost piece of a pier or pile bent serving to distribute the loads upon the columns or piles and to hold them in their proper relative positions; see Pier Cap, Pile Cap.

Capstone - The topmost stone of a masonry pillar, column, or other structure requiring the use of a single capping element.

Cast-In-Place - The act of placing and curing concrete within formwork to construct a concrete element in its final position.

Cast Iron - Relatively pure iron, smelted from iron ore, containing 1.8 to 4.5 percent free carbon, and cast to shape.

Catenary - The curve obtained by suspending a uniform rope or cable between two points.

Cement - A powder that hardens when mixed with water; an ingredient used in concrete.

CCC (Civilian Conservation Corps) - A work program established by the Federal government during the Great Depression (1929-1938) existing from 1933 to 1942. The CCC built roads, bridges, and structures and completed many conservation projects throughout the United States. Many CCC constructed structures are historically significant.

Cement Mortar - A mixture of four parts sand to one part cement with enough water added to make it plastic.

Channel - A rolled member of steel or iron forming a squared "C" shape.

Chord - The upper and lower horizontal components of the truss, forming the top and bottom of the truss webbing. The upper chord is in compression, the lower chord, in tension.

Clear Span - The unobstructed space or distance between support elements of a bridge or bridge member.

Coating - A material that provides a continuous film over surface; a film formed by the material.

Collision Strut - A diagonal member placed at the end panels of a truss bridge with inclined endposts to protect the latter from buckling if hit (as in a vehicle collision).

Component - A general term reserved to define a bridge deck, superstructure, or substructure; subcomponents, e.g., floor beams are considered elements.

Compression Members - Stiff, heavy members that withstand the pressure which tends to push them together.

Concrete - A mixture of aggregate, water, and a binder, usually portland cement, that hardens to a stone-like mass.

Continuous Beam - A general term applied to a beam that spans uninterrupted over one or more intermediate supports.

Continuous Bridge - A bridge designed to extend without joints over one or more interior supports.

Continuous Spans - Spans designed to extend without joints over one or more intermediate supports.

Continuous Truss - A truss having its chord and web members arranged to continue uninterrupted over one or more intermediate points of support.

Coping - A course of stone laid with a projection beyond the general surface of the masonry below it and forming the topmost portion of a wall; a course of stone capping the curved or V-shaped extremity of a pier, providing a transition to the pier head proper; when so used, it is commonly termed the "starling coping," "nose coping," the "cutwater coping," or the "pier extension coping."

Corbel - A piece constructed to project from the surface of a wall, column, or other portion of a structure to serve as a support for another member, or as a decorative element.

Counter - A diagonal member designed to limit the reversal of stress in the diagonals. Counters are smaller than diagonals and run in the opposite direction.

Counterfort - A bracket-like wall projecting from a retaining wall on the side of the retained material to stabilize it against overturning-, a counterfort, as opposed to a buttress, acts entirely in tension.

Counterforted Abutment - An abutment which develops resistance to bending moment in the stem by use of conterforts; this permits the breast wall to be designed as a horizontal beam or slab spanning between counterforts, rather than as a vertical cantilever slab.

Counterweight - A weight which is used to balance the weight of a movable member; in bridge applications, counterweights are used to balance a movable span so that it rotates or lifts with minimum resistance.

Cover Plate - A metal plate used to fasten other pieces together in a built-up member.

Covered Bridge - An indefinite term applied to a wooden bridge having its roadway protected by a roof and enclosed sides.

Crib - A structure consisting of a foundation grillage combined with a superimposed framework providing compartments or coffers which are filled with gravel, concrete, or other material, satisfactory for supporting the structure to be placed thereon.

Cross Bracing - Transverse bracings between two main longitudinal members; see *Diaphragm*.

Cross Girders - Girders that supply transverse support for longitudinal beams or girders.

Crown of the Roadway - The vertical dimension describing the total amount of the surface that is convex or raised from gutter to centerline; this is sometimes termed the cross fall of the roadway.

Curb - A short barrier paralleling the outside edge of the roadway to guide the movement of vehicle wheels and safeguard constructions and pedestrian traffic existing outside the roadway limit from collision with vehicles and their loads.

D

Deck - The portion of a bridge that provides direct support for vehicular and pedestrian traffic.

Deck Bridge - A bridge in which the supporting members are all beneath the roadway.

Diagonal - A sloping structural member of a truss or bracing system.

Diagonal Stay - A cable support in a suspension bridge extending diagonally from the tower to the roadway system to add stiffness to the structure and diminish the deformations and undulations resulting from traffic service.

Diagonal Tension - The principal tensile force due to horizontal and vertical shear in a beam.

Diaphragm Wall - A wall built transversely to the longitudinal centerline of a spandrel arch serving to tie together and reinforce the spandrel walls and providing a support for the floor system in conjunction with the spandrel walls; also known as cross wall.

E

Embankment - A bank of earth constructed above the natural ground surface to carry a road or to prevent water from passing beyond desirable limits; also known as bank.

End Post - The end compression member of a truss, either vertical or inclined in position and extending from the top chord to the bottom chord.

Expansion Joint - A joint designed to provide means for expansion and contraction movements produced by temperature changes, load, or other forces.

Extrados - The upper or exterior curve of an arch.

Eyebar - A member consisting of a rectangular or round bar with enlarged forged or stamped ends having holes through them for engaging connecting pins.

F

Fascia - An outside covering member designed on the basis of architectural effect rather than strength and rigidity, although its function may involve both.

Filled-Spandrel Arch - A stone or reinforced-concrete arch span having spandrel walls to retain the spandrel fill or to either entirely or in part support the floor system of the structure when the spandrel is not filled.

Fish Belly - A term applied to a girder or a truss having its bottom flange or its bottom chord constructed either haunched or bow-shaped with the convexity downward; see *Lenticular Truss*.

Flange - The horizontal parts of a rolled I- beam or built-up girder extending transversely across the top and bottom of the web.

Footing - The enlarged, lower portion of a substructure that distributes the structure load either to the earth or to supporting piles; the most common footing is the concrete slab; footer is a local term for footing.

Foundation - The supporting material upon which the substructure portion of a bridge is placed.

Frame - A structure having its parts or members arranged and secured so that the entire assemblage is not distorted when supporting the loads, forces, and physical pressures considered in its design.

G

Gauge - The distance between parallel lines of rails, rivet holes, etc; a measure of thickness of sheet metal, or wire; also known as gage.

Girder - A flexural member that is the main or primary support for the structure and usually receives loads from floor beams and stringers; any large beam, especially if built up.

Girder Bridge - A bridge whose superstructure consists of two or more girders supporting a separate floor system, as differentiated from a multi-beam bridge or a slab bridge.

Gravity Abutment Wall - A heavy abutment wall which resists horizontal earth pressure through its own dead weight.

Grid Flooring - A steel floor system comprising a lattice pattern that may or may not be filled with concrete.

Groin - A wall built out from a river bank to check scour.

Grout - A mortar having a sufficient water content to render it a free-flowing mass, used for filling (grouting) the joints in masonry, for fixing anchor bolts, and for filling cored spaces where water may accumulate.

Guardrail - A structural element designed to redirect an errant vehicle onto the roadway (guiderail).

Gusset - A plate connecting the members of a structure and holding them in correct position at a joint.

H

Half-Hip - A truss with inclined end posts that do not extend the length of a full panel.

Hammerhead Pier - A pier with a single cylindrical or rectangular shaft and a relatively long, transverse cap; also know as a tee pier.

Hand Rail - Commonly applied only to sidewalk railing having a latticed, barred, balustered, or other open web construction.

Hanger - A tension member serving to suspend an attached member.

Haunch - An increase in the depth of a member usually at points of support; the outside areas of a pipe between the spring line and the bottom of the pipe.

H-Beam - A rolled steel member having an H-shaped cross section and commonly used for piling; also known as H-pile.

Hinge - A point in a structure at which a member is free to rotate.

Hinged Joint - A joint constructed with a pin, cylindrical segment, spherical segment, or other device permitting movement by rotation.

Howe Truss - A type of bridge truss, having parallel chords, vertical (tension) rods at the panel points, and diagonals forming an X-pattern.

I

I-Beam - A structural member with a cross-sectional shape similar to the capital letter "I."

Integral Abutment - An abutment cast monolithically with the end diaphragm of the deck; such abutments usually encase the ends of the deck beams and are pile supported.

Integral Deck - A deck designed to share the load-carrying capabilities of the bridge with the superstructure and not merely to transfer loads to the superstructure.

Intrados - The inner or inside curve of an arch.

Iron - A metallic element used in cast or wrought iron and steel.

J

Joint - In stone masonry, the space between individual stone; in concrete, a division in continuity of the concrete; in a truss, the point at which members of a truss frame are joined.

K

Keystone - The symmetrically shaped, wedge-like stone located in the head ring at the crown of an arch; the final stone placed, thereby closing the arch.

King Post Truss - Two triangular panels with a common center vertical; the simplest design for a triangular truss.

Kip - A unit of weight equal to 1,000 pounds; convenient unit for structural calculations.

Knee Brace - A short member engaging two other members at its ends that are joined to form a right angle or a near-right angle to strengthen and stiffen the connecting joint.

L

Lacing - A zig-zag pattern, often used for battens when constructing a built-up truss member.

Laminated Timber - Small timber planks glued together to form a larger member.

Lateral Bracing - The bracing assemblage engaging a member perpendicular to the plane of the member-, intended to resist lateral movement and deformation; also provides resistance against raking of primary parallel elements in truss bridges and girder bridges; see *Bracing*.

Lattice - A crisscross assemblage of diagonal bars, channels, or angles on a truss. Also known as latticing.

Lenticular Truss - A truss having parabolic top and bottom chords curved in opposite directions with their ends meeting at a common joint.

Lower Chord - The bottom horizontal component of a truss.

M

Macadam - Uniformly sized stones rolled to form a road. Sometimes mixed with tar before application.

Main Beam - A beam which supports the span and bears directly onto a column or wall.

Masonry - That portion of a structure composed of stone, brick, or concrete block placed in layers and in some cases cemented with mortar.

Materials - The elements originally combined to make the structure.

Member - An individual angle, beam, plate, or built piece intended to become an integral part of an assembled frame or structure.

Monolithic - A single mass formed without joints.

Mortar - A paste of cement, sand, and water laid between bricks, stones, or blocks.

O

Open-Spandrel Arch - A bridge having open spaces between the deck and the arch members allowing "open" visibility through the bridge.

Open Spandrel Ribbed Arch - A structure in which two or more comparatively narrow arch rings, called ribs, function in the place of an arch barrel; the ribs are rigidly secured in position by arch rib struts located at intervals along the length of the arch-, the arch ribs support the columns that support the floor system and its loads.

Overpass - A bridge structure where the major thoroughfare is the upper roadway; see *Underpass*.

P

Panel - The portion of a truss span between adjacent points of intersection of web and chord members.

Panel Point - The point of intersection of primary web and chord members of a truss.

Parabolic Arch - An arch in which the inside surface is a segment of a symmetric parabola (common in concrete arches).

Parabolic Truss - A polygonal truss having its top chord and end post vertices coincident with the arc of a parabola, its bottom chord straight and its web system either triangular or quadrangular; also known as a parabolic arched truss.

Parapet - A low wall along the outmost edge of the roadway of a bridge to protect vehicles and pedestrians.

Phoenix Column - A built-up member made from curved pieces of iron riveted together to form a column. A patented design used for compression members.

Pier - A substructure unit that supports the spans of a multi-span superstructure at an intermediate location between its abutments.

Pier Cap - The topmost portion of a pier that distributes the concentrated loads from the bridge uniformly over the pier.

Pile - A shaft-like linear member that carries loads through weak layers of soil to those which are capable of supporting such loads.

Pile Bent - A row of driven or placed piles with a pile cap to hold them in their correct positions; see *Bent*.

Pile Bridge - A bridge resting on piles or pile bents.

Pile Cap - The uppermost portion of a pile that acts to secure the piles in position and provides a bridge seat to receive and distribute superstructure loads.

Pin - A cylindrical bar used to connect.

Pin-Connected Truss - A general term applied to a truss of any type having its chord and web members connected at the panel points by pins.

Plain Concrete - Concrete with no structural reinforcement except light steel to reduce shrinkage and temperature-related cracking.

Plate Girder - A large I-beam composed of a solid web plate with flange plates attached to the web plate by flange angles or fillet welds.

Polygonal - A general term applied to a truss of any type having a polygonal arrangement of its top chord members, coupled with a horizontal lower chord. Many polygonal truss types have their own names (e.g., Parker, Pennsylvania).

Pony Truss - A through truss having insufficient height to use a top chord system of lateral bracing.

Portal - The clear, unobstructed space of a through-truss bridge forming the entrance to the structure.

Portal Bracing - Diagonal bracing found at the edge of a through truss, designed to resist horizontal forces; see *Sway Bracing*.

Pratt Truss - A truss with parallel chords and a web system composed of vertical posts with diagonal ties inclined outward and upward from the bottom-chord panel points toward the ends of the truss.

Precast Concrete - Concrete members which are cast and cured before being placed into their final position on a construction site.

Prestressed Concrete - Concrete in which cracking and tensile forces are greatly reduced by compressing it with tensioned cables or bars.

Q

Queen-Post Truss - A parallel-chord type of truss having three panels with the top chord occupying only the length of the center panel; unless center panel diagonals are provided, it is a trussed beam.

R

Railing - A fence-like construction built at the outermost edge of the roadway or the sidewalk portion of a bridge to protect pedestrians and vehicles; see *Handrail*.

Reinforced Concrete - Concrete with steel reinforcing bars bonded within it to supply increased tensile strength and durability.

Reinforcement - Rods or mesh embedded in concrete to strengthen it.

Retaining Wall - A structure designed to restrain and hold back a mass of earth.

Rib - Curved structural member supporting a curved shape or panel.

Rigid-Frame Bridge - A bridge with moment resistant connections between the superstructure and the substructure to produce an integral, elastic structure.

Rip-Rap - Gabions, stones, blocks of concrete, or other protective covering material of like nature deposited upon river and stream beds and banks, lake, tidal, or other shores to prevent erosion and scour by water flow, wave, or other movement.

Rivet - A metal fastener used in pre-1970 construction; made with a rounded preformed head at one end and installed hot into a predrilled or punched hole; the other end was hammered into a similar shaped head, thereby clamping the adjoining parts together.

Riveted Connection - A rigid connection of metal bridge members that replaced pin connections using rivets. The riveted connection increases the strength of the structure.

Roadway - The portion of the road intended for the use of vehicular traffic.

Rocker - A type of bearing used to provide longitudinal movement.

Rolled-Steel Section - Any hot-rolled steel section including wide flange shapes, channels, angles, etc.

Roller - A steel cylinder intended to provide longitudinal movements by rolling contact. Ball bearings can substitute for steel cylinder.

S

Saddle - A member located upon the topmost portion of the tower of a suspension bridge that acts as a bearing surface for the catenary cable passing over it.

Scupper - An opening in the floor portion of a bridge to provide means for rain or other water accumulated upon the roadway surface to drain through it into the space beneath the structure.

Seat - A base on which an object or member is placed.

Secondary Member - A member that is carried by other members and does not resist traffic loads.

Segmental - Constructed of individual pieces or segments that are collectively joined to form the whole.

Simple Span - The span of a bridge or element that begins at one support and ends at an adjacent support.

Slab Bridge - A bridge having a superstructure composed of a glue-laminated timber slab or a reinforced concrete slab constructed either as a single unit or as a series of narrow slabs placed parallel to the roadway and spanning the space between the supporting abutments.

Soldier Beam - A timber or steel pile driven into the earth with its projecting butt end used as a cantilever beam.

Span - The distance between piers, towers, or abutments.

Spandrel - The space bounded by the arch extrados and the horizontal member above it.

Spandrel Column - A column constructed on the rib of an arch span and serving as a support for the deck construction of an open spandrel arch; see *Open-Spandrel Arch*.

Spur Dike - A projecting jetty-like construction placed upstream and adjacent to an abutment to prevent stream scour and undermining of the abutment foundation and to reduce the accumulation of stream debris against the upstream side of the abutment.

Stay-In-Place Forms - A prefabricated metal concrete deck form that will remain in place after the concrete has set.

Steel - An alloy of iron, carbon, and various other elements and metals.

Stiffening Girder - A girder incorporated into a suspension bridge to distribute the traffic loads uniformly among the suspenders and to reduce local deflections; see *Girder*.

Stiffening Truss - A truss incorporated into a suspension bridge to distribute the traffic loads uniformly among the suspenders and to reduce local deflections; see *Truss*.

Stirrup - U-shaped bar providing a stirrup-like support for a member in timber and metal bridges; U-shaped bar placed in concrete construction to resist diagonal tension (shear) stresses.

Stone Masonry - The portion of a structure composed of stone.

Stub Abutment - A short abutment often supported upon piles or on gravel fill, the embankment, or natural ground

Stringer - A longitudinal beam supporting the bridge deck.

Structural Member - An individual piece, such as a beam or strut, that is an integral part of a structure.

Structure - Something, such as a bridge, that is built and designed to sustain a load.

Strut - A piece or member acting to resist compressive stress.

Subdivided Panels - Panels in a truss bridge with intermediate diagonals and/or verticals to provide additional support, as in a Baltimore or Pennsylvania truss.

Superelevation - The difference in elevation between the inside and outside edges of a roadway in a horizontal curve; required to counteract the effects of centripetal force.

Superstructure - The entire portion of a bridge structure that primarily receives and supports traffic loads and in turn transfers these loads to the bridge substructure.

Suspended Span - A simple span supported from the free ends of cantilevers.

Suspender - A wire cable, a metal rod, or bar connecting to a catenary cable of a suspension bridge at one end and the bridge floor system at the other, thus transferring loads from the road to the main suspension members.

Suspension Bridge - A bridge in which the floor system is supported by catenary cables that are supported upon towers and are anchored at their extreme ends.

Suspension Cable - A catenary cable that is one of the main members upon which the floor system of a suspension bridge is supported.

Sway Anchorage - A guy, stay cable, or chain attached to the floor system of a suspension bridge and anchored upon an abutment or pier to increase the resistance of the suspension span to lateral movement; also know as sway cable.

Sway Bracing - Diagonal bracing located at the top of a through truss, perpendicular to the truss itself, usually in a vertical plane, and designed to resist horizontal forces.

T

Tendon - A prestressing cable, strand, or bar.

Tension Members - Slender members of a bridge that resist forces that pull them apart.

Three-Hinged Arch - An arch that is hinged at each support and at the crown.

Through Bridge - A bridge where the floor elevation is nearly at the bottom of the superstructure and traffic travels "through" the supporting parts.

Tie - A member carrying tension.

Timber - Wood suitable for building purposes.

Tower - A pier or frame supporting the catenary cables of a suspension bridge.

Travel Way - The roadway.

Trestle - A bridge structure consisting of spans supported upon frame bents.

Truss - A jointed structure made up of individual members arranged and connected, usually in a triangular pattern, so as to support longer spans.

Truss Bridge - A bridge having a pair of trusses for the superstructure.

Trussed Beam - A beam stiffened to reduce its deflection by a steel tie-rod that is held at a short distance from the beam by struts.

Tunnel - An underground passage open to daylight at both ends.

Turnbuckle - A long, cylindrical, internally threaded nut used to connect the elements of adjustable rods and bar members.

Two-Hinged Arch - A rigid frame that may be arch-shaped or rectangular but is hinged at both supports.

U

U-Bolt - A bar bent in the shape of the letter "U" and fitted with threads and nuts at its ends.

Underpass - A bridge structure where the principal, or subject, transportation facility is the lower roadway; see Overpass.

Upper Chord - The top longitudinal component of a truss.

United States Department of the Interior
National Park Service

National Register of Historic Places Continuation Sheet

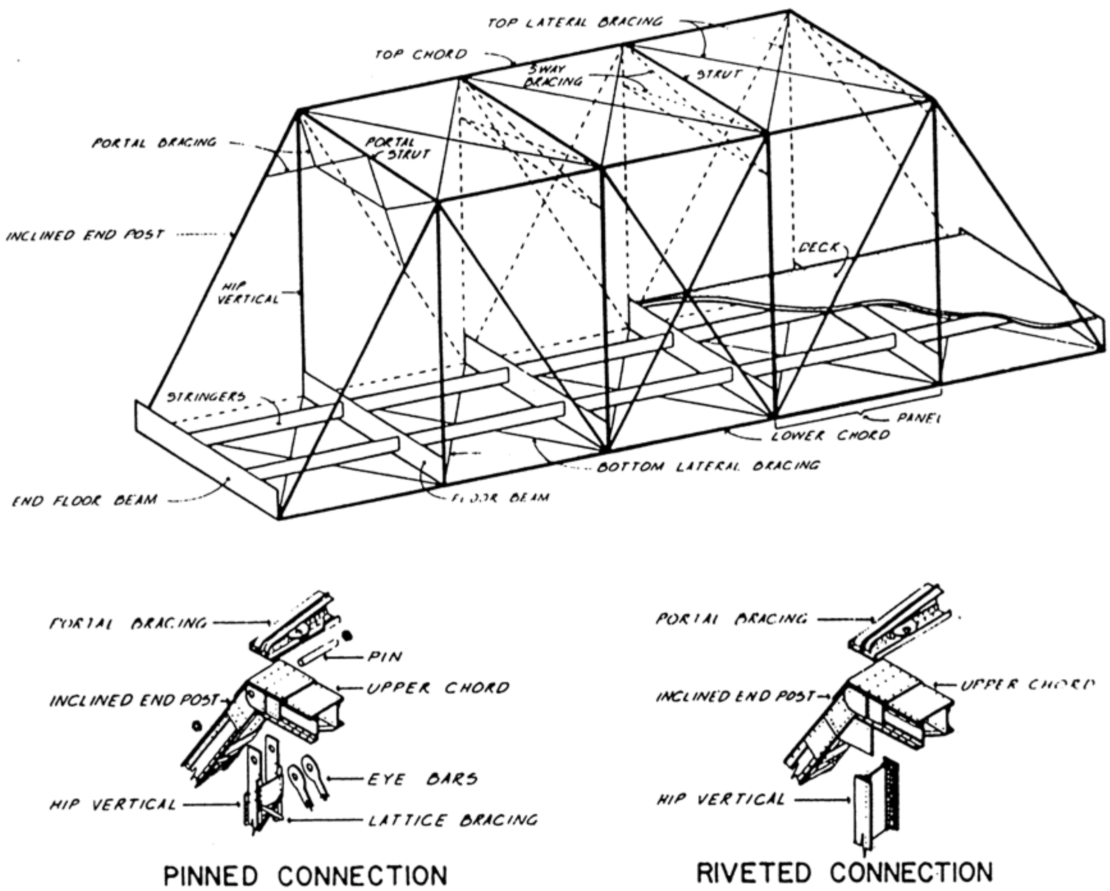


Figure 18. Diagram of a bridge truss. Historic American Engineering Record.

V

Vertical - A member resisting compressive stresses located vertical to the bottom chord of a truss and common to two-truss panels-, sometimes used synonymously with vertical column.

Viaduct - A series of spans carried on piers at short intervals.

Voussoir **-** One of the truncated wedge-shaped stones of which a stone arch is built; also known as a ring stone.

Voussoir Arch **-** An arrangement of wedge-shaped blocks set to form an arched bridge.

W

Warren Truss - A triangular truss consisting of sloping members between the top and bottom chords, with or without vertical members; members form the letter W.

Waterway - The available width for the passage of water beneath a bridge.

Wearing Surface - The topmost layer of material applied upon a roadway to receive traffic loads and to resist the resulting disintegrating action; also known as wearing course.

Web - The portion of a beam located between and connected to the flanges; the stem of a dumbbell pier.

Web Members - The intermediate members of a truss, not including the end posts, usually vertical or inclined.

Welded Bridge Structure - A structure whose metal elements are connected by welds.

Welded Joint - A joint in which the assembled elements and members are united through fusion of metal.

Wheel Guard - A raised curb along the outside edge of traffic lanes to safeguard constructions outside the roadway limit from collision with vehicles.

Whipple Truss - A double-intersecting through Pratt truss where the diagonals extend across two panels.

Wide Flange - A rolled, I-shaped member having flange plates of rectangular cross section, differentiated from an S-beam (American Standard) in that the flanges are not tapered.

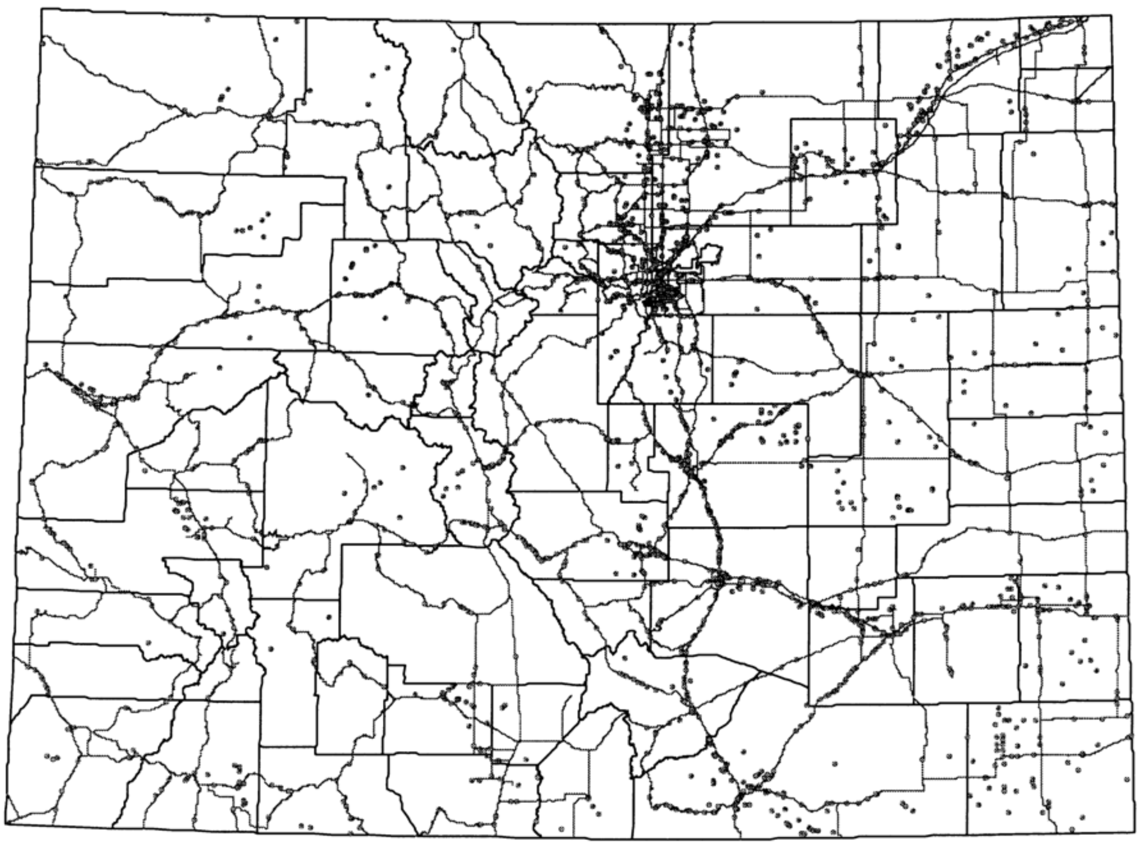
Wind Bracing - The bracing systems that function to resist the stresses induced by wind forces.

Wingwall - The retaining wall extension of an abutment intended to restrain and hold in place the side-slope material of an approach roadway embankment.

National Register of Historic Places
Continuation Sheet

Geographic Data; State of Colorado (see map)

Dots represent 2,158 bridges surveyed



Summary of Identification and Evaluation Methods

The Colorado Historic Bridge Inventory, which formed the basis for this Multiple Property Documentation Form, was produced for the Colorado Department of Transportation by Fraserdesign of Loveland, Colorado. The study was undertaken with the cooperation of the Colorado State Historic Preservation Office, a division of the Colorado Historical Society. This inventory was a sequel to an earlier study completed in the early 1980s by Fraserdesign that focused primarily on identifying National Register-eligible bridges constructed before 1945 from four major categories: trusses, arches, concrete girders and steel girders. This follow-up study broadened the scope of the original inventory to include highway bridges of all structural types, and it lengthened the time frame to examine bridges built before 1959. The study inventoried and evaluated highway bridges and grade separations currently in use on the state, county, and city road systems. Generally not included were railroad bridges, bridges in private ownership, and those that have been dismantled or permanently closed to vehicular traffic. There were exceptions to this, however, and several abandoned and/or privately owned structures of special importance were included.

By inventorying structures on a statewide basis, the study provided a database and the contextual background by which individual structures could be evaluated for historical and technological significance. This information will aid long-range policy and funding decisions at the outset of the planning process and allow enlightened, streamlined review of proposed maintenance, rehabilitation, and replacement projects. Additionally, it will help to guide mitigation measures for future construction projects that affect eligible structures.

The inventory began with production of a customized computer database from the CDOT Structure Inventory and Appraisal general database. With the general list of bridges in hand, the next step was to conduct research that would establish a historical context and would delineate important historical and technological trends to provide a point of comparison for evaluation of individual structures. Preparation of the historical context required extensive research at a number of repositories, including the CDOT files, archives, and library, public libraries around the State, and city and county record centers. Contextual information relating to Criteria A and C provided the parameters for sorting the bridge database to identify a cross-section of potentially eligible bridges that merited field survey. The survey list was further refined by a review of photographs of every bridge built prior to 1959. This review eliminated bridges with obvious integrity problems and added bridges to the list with aesthetic features that could not be identified by the computer database. Out of a total of 2158 pre-1959 bridges in the State, some 420 were included this way in the survey sample.

Surveyors visited every bridge in the survey sample, recording each bridge with field notes, 35mm color slides, and medium-format black-and-white photographs. They also completed additional research, when necessary, at local archives and record centers. For every one of the 2158 bridges in the inventory a one-page inventory form was prepared, presenting locational, structural, and historical information, as well as a location map. For each of the 420 bridges recommended by the consultants as potentially eligible for the National Register, an expanded form was produced, which presented a more detailed construction history, statement of significance and list of references. Two or more photographs of the structure were attached to each of the expanded inventory forms.

National Register eligibility for each bridge was evaluated according to registration requirements outlined in Section F of this MPDF. Using these criteria for significance and integrity, 181 structures were identified as eligible for the National Register. Additionally, 37 structures were identified as having been previously listed in the National Register as part of the original bridge inventory. As a last step in the process, the list of structures recommended for National Register eligibility was presented to a Historic Bridge Advisory Board in September 2000.

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