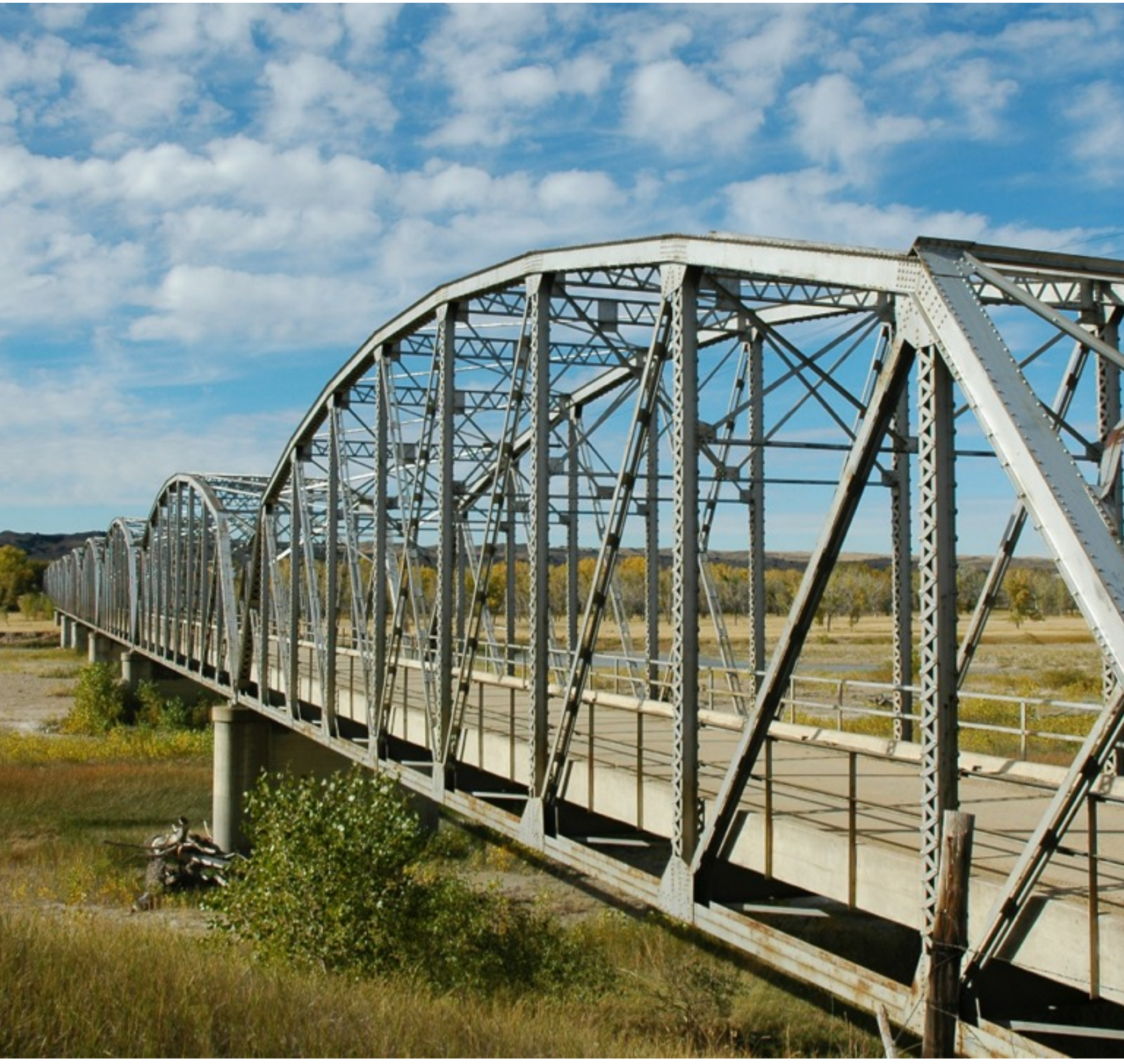

PRAIRIE CROSSINGS

SOUTH DAKOTA'S HISTORIC ROADWAY BRIDGES

SOUTH DAKOTA DEPARTMENT OF TRANSPORTATION

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The primary component of this study was a tremendous fieldwork effort, largely conducted by employees of Renewable Technologies, Inc. (RTI), a Montana-based cultural resources consulting firm. RTI staffers spent untold weeks driving South Dakota's highways and backroads, ultimately visiting the sites of over 2,500 bridges in virtually every corner of the state. Much of this fieldwork was completed by RTI employees Mark Hufstetler, Jennie Goff Frankus, and Ken Dickerson. Gregg Ninefeldt, RTI's GIS tecnician, provided maps for the project.

This document relies heavily on the research and conclusions produced during three earlier RTI studies of South Dakota bridges, and some of the text in this volume is drawn from those reports. Numerous RTI employees contributed to the earlier studies, including Mark Hufstetler, Fred Quivik, Dale Martin, and Lon Johnson.

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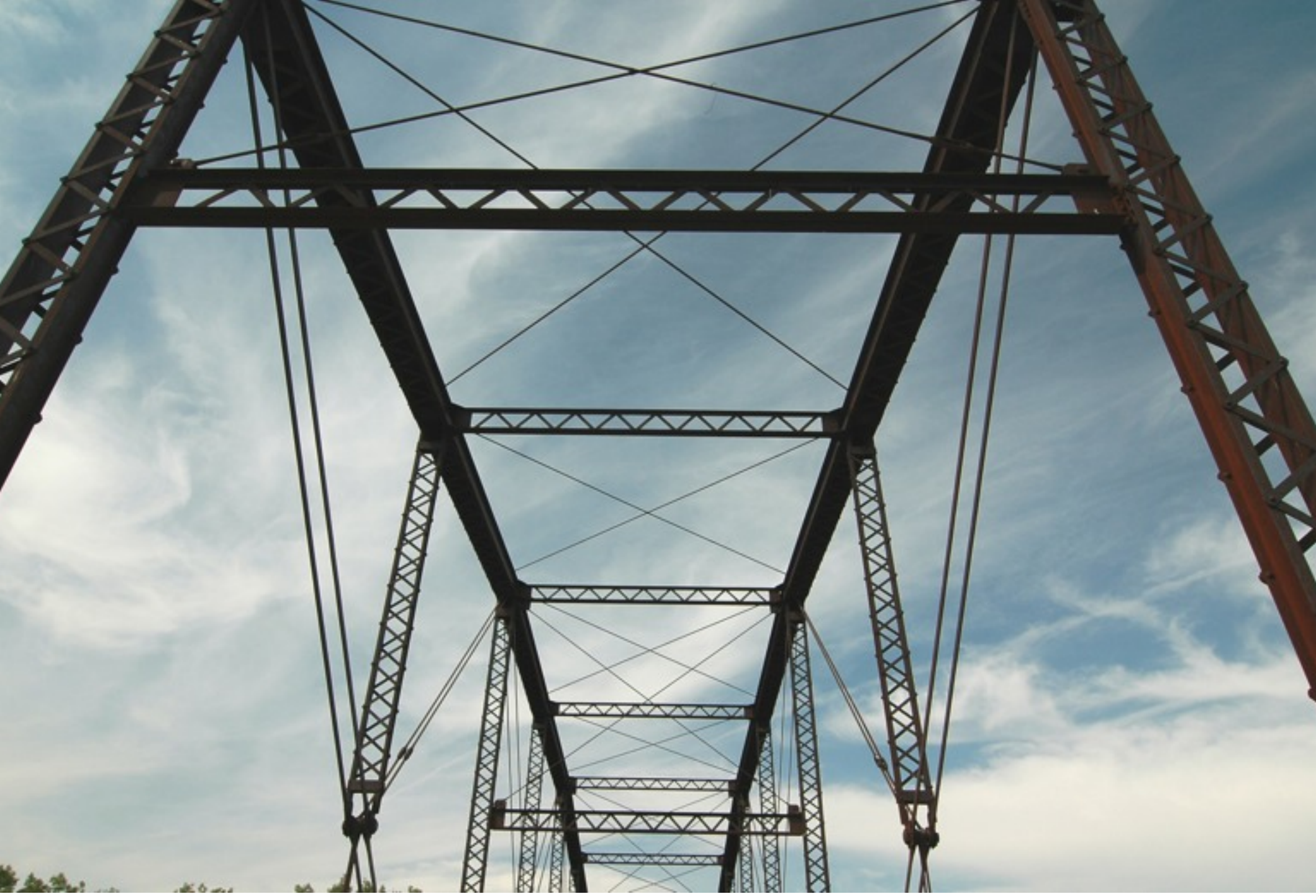


1

INTRODUCTION:

LOOKING AT BRIDGES

Landmarks

South Dakota is among the younger of the United States, a land where only very scattered areas have seen more than a few generations of written history. Many of the state's people still see themselves as pioneers, and justifiably so; they live and work and travel on a landscape that often seems little changed from that seen by the first white settlers, or by the indigenous peoples who preceded them. To

the casual observer, much of the state bears few visible reminders of the past – just scatterings of deserted homesteads, some dying prairie towns, and a few abandoned railroad grades melting into the earth.

There are many other reminders of South Dakota's history dotting the countryside, though – structures and objects and landscapes that can tell us much about our past, though we seldom consciously notice them. In the vast rural expanses of the state, the grid of section-line roads and fences is perhaps the land's most characteristic, defining feature. A travel corridor every mile, east and west, north and south – it was a key pattern of pioneer settlement throughout the American Midwest. These section-line routes were key to settlement and livelihood in the rural prairies, connecting farms and neighboring villages and eventually joining to create longer roads that ultimately traversed the state. Many of them remain today, still filling the need they were first created to address. They are important, if unremarked, historic elements on the landscape.

Although much of South Dakota is a land of subtle geography, a variety of obstacles still complicated the development and improvement of the state's roadway grid. Rivers and streams were easily the most common barriers to travel, and during the last half of the nineteenth century South Dakota's county, township, and municipal governments developed increasingly ambitious bridge construction programs as part of their roadway improvement efforts. These bridges were among the most visible and substantial civic projects of the era, and were a focus of both governmental and public attention. Bridge projects eased local travel and were economic and lifestyle assets to nearby residents, and major bridges – usually intricate truss designs – became known as local landmarks.

As South Dakota continued to improve its road and highway network during the twentieth century, bridge construction remained a major element of the improvement efforts. Improved financing and advances in bridge technology allowed for the construction of more and larger spans, and state involvement in the process saw increased standardization of bridge design. While there was less "uniqueness" to most bridges constructed in these later years, other landmarks still appeared, including a series of massive, state-built bridges spanning the Missouri River. Again, those bridges were among the largest and most important state-sponsored projects of their era.

Previous page: the structural members of a Parker through truss bridge, east of Belle Fourche.

And the process or road improvement and bridge construction continues. The original grid of section-line roads that once crisscrossed most of the state is less prominent now, as rural settlement thins and unneeded roadways are abandoned. Meanwhile, South Dakota's long-distance highway network has assumed a greater importance, and the interstate high-

way overpass has for many travelers become the quintessential South Dakota bridge. Most of us drive past those modern structures today without noticing. There's no doubt, though, that bridges old and new continue to be vital components of the state's transportation network, and a few bridges are still regarded as visual landmarks on the South Dakota landscape.

Looking at the state's bridges in the context of their history, though, it becomes easy to recognize that that even the structures we pass by unnoticed have an importance. Individually and as a group, South Dakota's bridges are reminders of the long pattern of our state's transportation history, and of the importance we place on good roads and on the ability to travel. For well over a century now, the construction and maintenance of roadway bridges has been a major effort of our state and local governments, and it will certainly remain so in the future. Simultaneously, many South Dakota bridges are important engineering works, either because of their magnitude, or simply because they are a tangible reminder of a largely forgotten technology of the past. It is this combination of qualities – strong historical associations and reminders of our engineering past – that makes South Dakota's bridges important from a cultural perspective, and its one of the reasons it's important for us to recognize them for the landmarks that they are.

A Variety of Bridges

Today, most of the bridges that South Dakota travelers see are supported by long girders of either steel or concrete – designs that are straightforward, efficient, and utilitarian. This uniformity is a relatively recent phenomenon, however; over the years the state's bridge engineers have employed a wide variety of designs in their projects, and examples of nearly all these style survive in South Dakota today. This historic variety is a strong characteristic of the bridge history, and is one of the reasons the topic is an intriguing one.

In South Dakota and elsewhere, bridges are commonly categorized in two ways: by the choice of material used in their superstructures, and by the engineering design of those superstructures. The earliest South Dakota bridges were made of wood, a material that was inexpensive and often locally available. Most wooden bridges were simple to design and build, but they had significant drawbacks, including a relatively short working life and an inability to create long-span structures. These limitations eventually reduced the number of wooden bridges built in South Dakota,

although many small wooden bridges still exist on lightly-used county roads.

The science of bridge design advanced dramatically in the late nineteenth century with the widespread incorporation of structural iron and steel in roadway bridge construction. Compared to wood, steel offers far greater strength and durability, and the ability to cast and assemble steel in a multitude of designs and lengths. This gave engineers the ability to design far larger bridges, and resulted in the development of literally dozens of truss designs, several of which are still present in the state today. Steel stringer and girder bridge were the predominant bridge type in South Dakota for much of the mid-twentieth century, and the material still sees use today.

The third primary building material for South Dakota bridges is concrete. First used in local bridges in the early twentieth century, concrete was initially used in culverts and small span structures that might have otherwise been built of wood, or in locations that called for decorative or innovative bridge designs – arch bridges, for example. As the technology improved, however, concrete began to be seen as a viable substitute for steel in the construction of larger, standard-plan bridges, and in recent years the concrete girder bridge has become nearly ubiquitous in the state. It has become the standard building material for bridges in the United States.

Bridge engineers have used each of these building materials in a variety of ways over the years, to design bridges of highly differing forms. The simplest design, usually called a “stringer” bridge, consists of a parallel series of longitudinal beams traversing the span, with the roadway resting

This three-span Parker through truss bridge, built in 1930, crosses the Cheyenne River in far eastern Custer County.

on the beams. Thousands of timber, steel, and concrete stringer bridges have been constructed in South Dakota over the years, and all three materials continue to be used in stringer bridges today. Initially used primarily for shorter spans, advances in steel and concrete technology now allow the stringer design to be used for all the longest spans.

The truss is perhaps the most visually-appealing bridge design, and the one most commonly associated with historic bridges in South Dakota. A truss bridge utilizes a framework of structural members to support the roadway, with the roadway generally resting on lateral support members at either the bottom or the top of the framework. Virtually all trusses in South Dakota are steel, although other materials have been used over the years. The arrangement of members in the truss framework can differ greatly among various designs, depending in part on factors such as span length and expected load. Truss designs were particularly important during the early years of bridge-building in South Dakota, because they allowed for construction of far longer spans than were possible with a stringer bridge, and consequently nearly all of the state's major nineteenth and early twentieth century bridges were trusses. Far fewer trusses were constructed in South Dakota in later years, as long-span stringer and girder designs became simpler and stronger. Though the number of truss bridges in South Dakota is diminishing, the survivors remain among the most striking and evocative structures in the state.

A third bridge type is the arch, relatively uncommon in South Dakota. Though arch bridges may be constructed from a variety of materials, most of the South Dakota arches are concrete. More exotic bridge types, including suspension and cable-stayed designs, are rare to non-existent in the state.

Added to this basic matrix of materials and designs are a variety of other structural and visual features – number of spans, guardrail designs, lighting, and so on. Together, they help define a resource that is often perceived as being largely homogenous and uniform, but actually displays a surprising and fascinating diversity. Combine this diversity with an unquestioned historic importance and the result is an intriguing subject, unquestionably worthy of study.

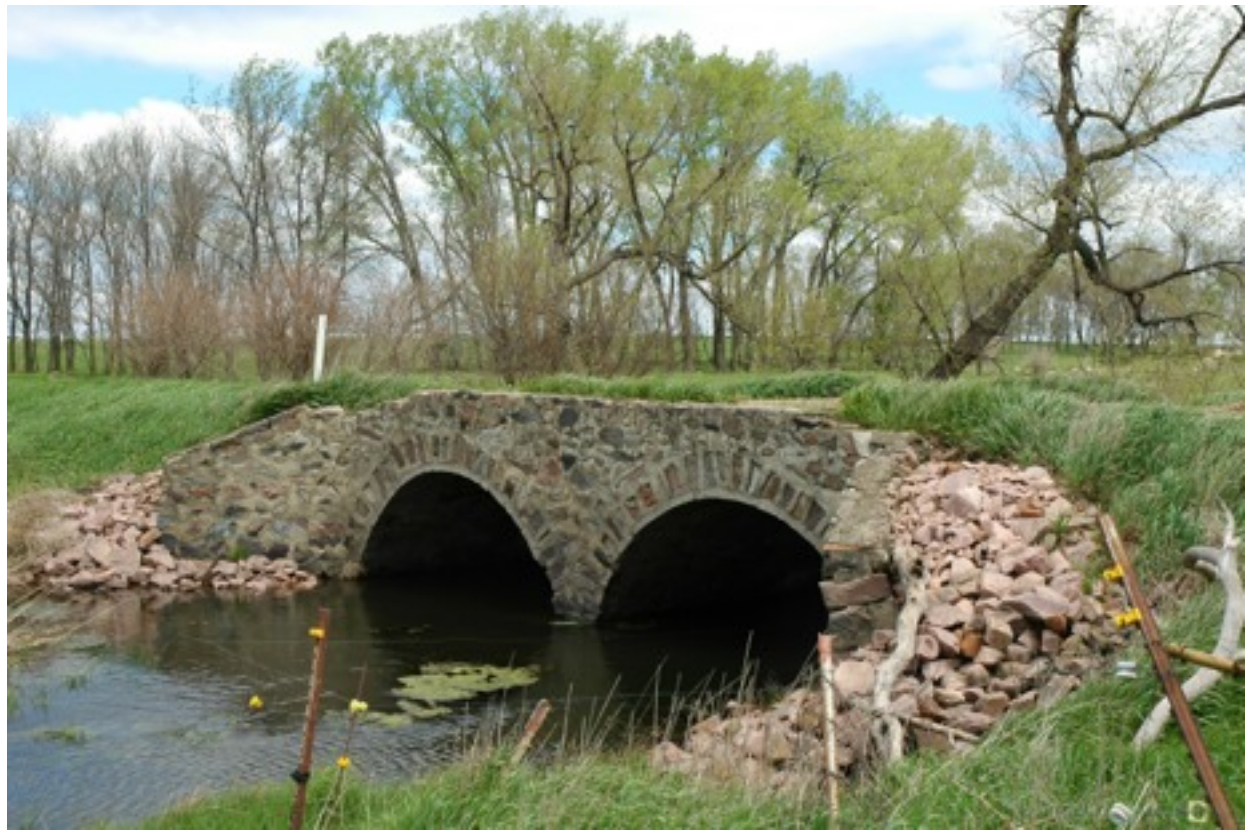
The South Dakota Bridge Inventory

The recognition of highway bridges as significant historic resources, both nationally and locally, has led to the understanding that their history deserves to be documented, and that particularly important bridges should

be considered for preservation. To encourage these goals, federal regulations require that bridges (and other historic resources) be carefully considered when highway projects are undertaken using federal monies. In recent years, state governments have designed a variety of programs to help meet these requirements, by contracting research, evaluation, and even restoration projects. For most states, the completion of a comprehensive bridge inventory is a cornerstone of its historic bridge program.

South Dakota completed its first statewide inventory of historic bridges in the late 1980s, and the results of that project have served the state well in the years since. By 2003, however, it was clear that the project was in need of an update; many of the bridges featured in the original report had been replaced, and many other structures had reached an age where their possible historic significance merited consideration. (Federal guidelines state that buildings and structures fifty years of age or older should generally be evaluated for their possible eligibility for listing in the National Register of Historic Places.)

A contract for the completion of such an update was awarded in 2003 to Renewable Technologies, Incorporated (RTI), a Montana-based consulting firm. As designed by SDDOT and RTI, the project called for the recordation and historic evaluation of all South Dakota bridges constructed prior to 1970. Nearly all bridges constructed prior to World War II were visited and recorded during the course of the project, along with a representative cross-section of more recent structures. In all, approximately 2,500 bridges and bridge sites were visited, in every county of the state.



Turner County boasts a number of handsome concrete-arch culverts constructed by public-works crews during the Great Depression -- among the state's most unique bridge structures.

Each bridge was described, photographed, and mapped, and its historic significance evaluated. This information was collated on an individual "site form" for each bridge, deposited in the files of the South Dakota State Historic Preservation Office. Together, this material constitutes the largest body of historic information on the state's bridges ever accumulated.

The material from this massive field survey was then aggregated and combined with additional research to construct a variety of products, including a document describing how historic bridges in the state should be evaluated, and another outlining procedures to mitigate the inevitable loss of some of the state's historic bridges in the future. The final product is the volume you are now reading, a brief overview of bridge construction in the South Dakota, and an appreciation of their importance to our history and our daily life. As more and more of the state's early bridges succumb to old age and increased highway demands, this volume and the other products of this project will serve as a reminder of a vanished era of transportation and engineering.

2

GETTING AROUND IN DAKOTA

The Land

The way a region is inhabited, utilized, and traversed always depends, at least in part, on its geography. The recent history of South Dakota is no exception; the state's landscape influenced the way people traveled here, what they did when they arrived, and how they developed. And while many of these patterns were reflective of those in other Midwestern states, South Dakota's unique landscapes played a pivotal role in shaping a surprisingly diverse cultural geography – one that is certainly not wholly Midwestern. Travel corridors and methods played a major part in that development, and continue to do so today.

The most prominent defining characteristic of South Dakota geography is clearly the Missouri River. It serves to divide the state into roughly equal eastern and western halves, each with distinct environmental characteristics. This environmental and physical divide also helped define varied patterns of development for "East River" and "West River," in ways that are still strongly seen today. East River landscapes are often more classically Midwestern, with shallow river valleys and almost endless horizons. Much of the land is suitable for farming, and travel is efficiently accomplished along straight lines. The rectangular grids of traditional federal land surveys fits the area perfectly, and helps reinforce the straight-line notion of development.

The West River country, in contrast, is distinctly more arid and rugged. Small farm units are less viable here, and geographic distinctions more highly visible. The increased variability of the landscape means that arbitrary rectangular divisions of the land make less sense, and the survey grid frequently imposes less of an impact on the visual landscape. Transportation is impacted as well – travel corridors are less tied to straight lines and compass directions, and more tied to the arrangement of landforms. The region's hills and deep river valleys can both ease and hinder movement, causing early travelers to more strongly take them into account. Development followed accordingly.

And there is also the Missouri River itself, which served as both a great travel corridor and a great transportation obstacle. The region's first Euro-American explorers entered Dakota on the river, and it was the region's only significant long-distance travel route until well into the nineteenth century. At least during the navigation season, the river served as Dakota's lifeline, and was the hub of its commerce. But as settlement and land travel grew, the river became an obstacle, unbridged until the twentieth century and impossible to cross for weeks or months every year. This increased the division between east and west, and briefly created a third Dakota geography – one centered on the river itself.

While this geographic diversity clearly had a strong role in molding the early settlement patterns of South Dakota, it was a hindrance to a more substantial level of development in the region, as well as to the economic, political, and cultural unification of the future state. To overcome this, a capable land-based transportation network was required – systems of roads and railways, along with the bridges and other structures needed to support them.

Previous page: long, arrow-straight unpaved roads have defined travel in much of South Dakota for over a century.

Early Settlement and Travel Patterns

The vagaries of Dakota's geography and landscape did not deter explorers and settlers lured by the vast plains. In 1738, Pierre Gaultier de Varennes, Sieur de la Verendrye, a fur trader and explorer, became probably the first Euro-American known to visit what is now South Dakota. David Thompson led a survey expedition to the area in 1797; his work was the basis for the north border of the western United States, which became fixed by a treaty with Great Britain in 1818. Around the beginning of the nineteenth century, various fur trading companies established posts throughout the area. By mid-century, the first attempts at permanent settlement were taking place in the far southeastern part of the future South Dakota state. Military forts brought more people to the region, particularly during the 1860s and 1870s, when local Indians became disgruntled by the influx of pioneers and gold prospectors. The varied needs of military, mining, and agriculture combined to create the first rudimentary network of overland trails in what was to become South Dakota, connecting forts with mining and supply centers. Undoubtedly, these routes also included the earliest bridges built in the state, although most of the roads were laid out to take advantage of fords or crossings.

The area's major rivers, although an impediment to land travel, served as a mode of transportation in their own right. On the Missouri, the steamboat “Yellowstone” joined the canoes and crude rafts of fur traders and explorers in 1832, when it ventured upstream as far as Fort Union (at the present North Dakota-Montana border). This route was continued and expanded in subsequent years. Steamboats carried passengers, provisions, and the produce of the newly broken fields on the plains. River traffic, always seasonal in nature lessened in importance after about 1873, when the Northern Pacific became the first railroad in Dakota Territory to reach the river from the east (at what is now Bismarck, North Dakota). The following decade saw additional railroad lines reach the river in what was to become South Dakota, portending the end of the steamboat. Very limited commercial river traffic continued in South Dakota as late as the 1930s.

The influence of steamboats on the settlement of South Dakota was necessarily small. Not only was the river season limited, but steamboat travel was unreliable, given fluctuating water levels, hostile Indians, shifting sandbars, and other obstructions. More importantly, much of Dakota was simply inaccessible to riverboats. It remained for the railroads to bring intensive Euro-American settlement to vast reaches of Dakota Territory.

The First Roads and Bridges

Prior to the early nineteenth century and the establishment of the Euro-American fur trade in the upper Midwest, the region's transportation network consisted of the trails and water routes of the Native Americans. The first trail documented in what was to become South Dakota was on a map made by DeLisle in 1701. Voyageurs, thought to be the first Europeans to enter South Dakota, followed this trail to the Sioux Falls. More than 100 years later, Joseph Nicollet, traveling along the James River in 1839, reported a trail worn deeply by the Sioux Indians dragging lodge poles. The following year, the Reverend Stephen R. Riggs and Alexander Huggins traveled an Indian trail up the Lac Qui Parle River in Minnesota to Two Woods Lake near present-day Altamont in Deuel County.

Euro-Americans who established settlements in the American West after the middle of the nineteenth century were not initially attracted to the Dakota prairies, and permanent roads were not needed to move supplies and soldiers westward through the region because of the summer availability of the Missouri River corridor. Early military expeditions into the Dakotas continued to use Indian trails. General Harney's 1855 military expedition from Laramie into South Dakota followed a long-established trail used by the Indians traveling between the Pierre area and the headwaters of the Platte River. The following year, a company of soldiers traveling from Fort Ridgley in Minnesota to Fort Pierre with Major Abercrombie undertook the first documented bridge construction in South Dakota. According to Doane Robinson, "They built a substantial bridge across the James River at Armadale, Spink County, which was no doubt the first bridge built in this region."

An early, unidentified timber through truss bridge in South Dakota.

In 1857 Minnesota entrepreneurs, aspiring to establish St. Paul as the eastern terminus of a Pacific railroad, obtained a Congressional appropriation to construct an emigrant road from that city to the Oregon Trail at South Pass, Wyoming – a route running via Fort Ridgley and passing by the present townsite of Woonsocket. It was their hope that a transcontinental railroad would follow. The Minnesotans completed the road as far as the Missouri River in November. They chose a route using good fords to make streams passable, obviating the need for bridges.

That same year, the Army established Fort Randall along the Missouri River on the South Dakota side of the Nebraska border. A military road served the fort from Sioux City via Elk Point, Vermillion, and Yankton. As it established other military posts, the Army connected them with a rudimentary network of roads. In 1865 the United States Congress authorized the improvement of the road to Fort Randall. Gideon C. Moody, who later became one of South Dakota's first U.S. Senators, used a portable sawmill to produce lumber for bridges at Sioux City, Vermillion, and the James River.

Given a sense of security by the presence of these and other military forts, settlers soon began to follow the Army into Dakota Territory, but river crossings presented problems for emigration, commerce, and the layout of public roads. Many roads were laid out to take advantage of fords or crossings that were already in use. As roads were improved over time, these same crossings often became the locations of bridges in later years. Ben Ash, for example, established the Bismarck Crossing of the Belle Fourche River in 1875 to serve a wagon road between the railroad at Bis-

An early timber stringer bridge, at an unidentified location.

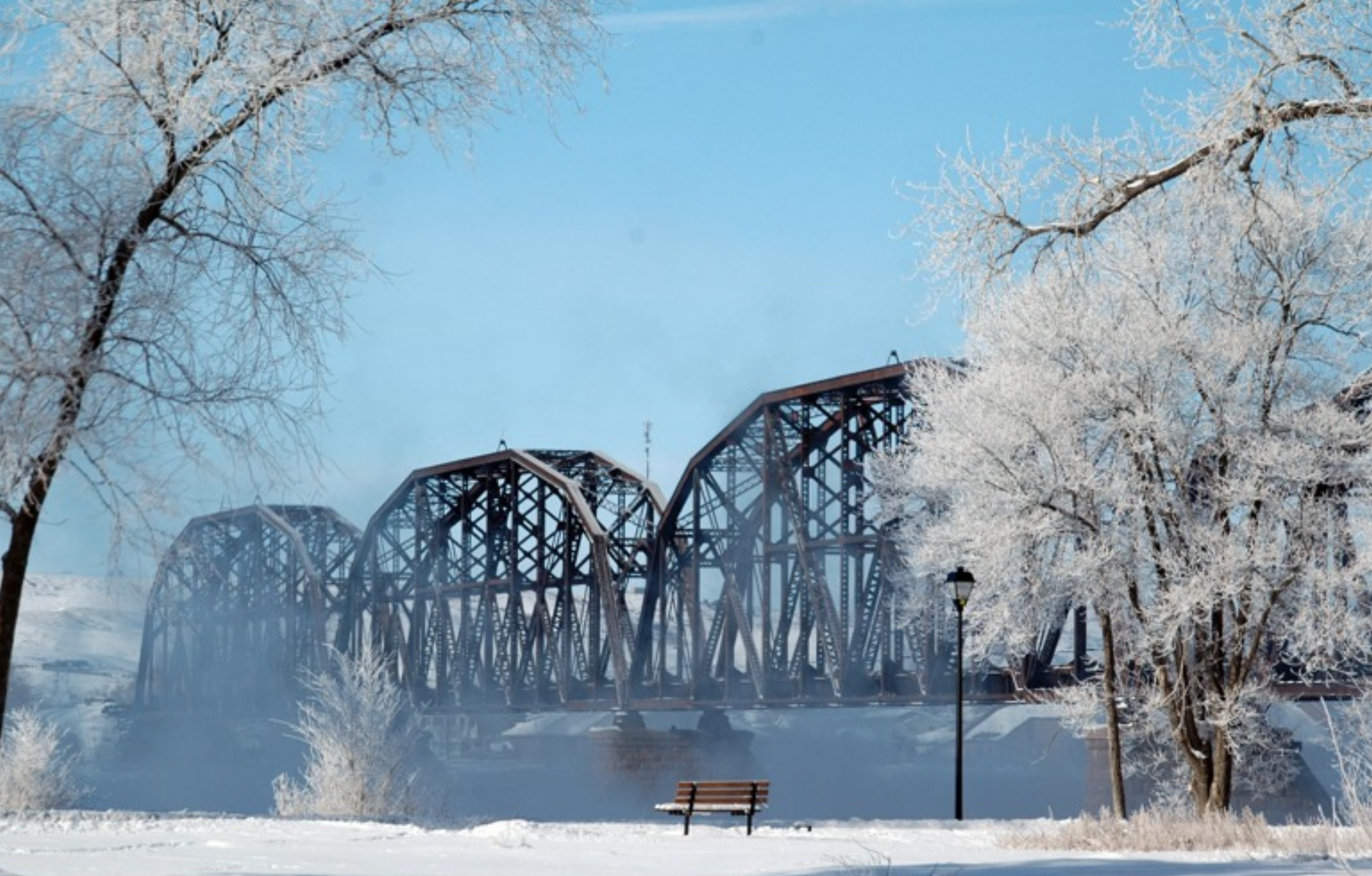
marck and the booming mining districts of the Black Hills. Ash received financial support for his venture from Bismarck businessmen seeking to benefit from trade with the Black Hills district. The ferry crossing was in turn replaced by the county-constructed Bismarck Bridge in 1912. Ferries such as this were prevalent at larger river crossings where fords were not practical; typically licensed by county governments, the ferries could only operate for a few months each year due to weather conditions. Despite this limited utility, though, ferry crossings were the only routes across rivers that were too large to ford during much of the nineteenth century. Except for a handful of military structures, relatively few bridges were built in the state until after statehood in 1889.

Eventually, though, the settlers and their local governments did begin to build bridges. The small number of structures built in the 1870s and 1880s were relatively short of span and temporary in nature. Local carpenters usually built small bridges that were rather crude wooden affairs, simple stringer designs on primitive substructures that were often unsound. Minnehaha and Hutchison Counties provide good examples of bridge-building practices in South Dakota during the early years of Euro-American settlement in the southeastern part of the state. In 1871, Minnehaha County voters approved a one-mill tax for the improvement of roads and bridges, and increased the tax to two mills for roads and one mill for bridges by 1878. County Commission records for that period reveal numerous requests from county road districts for bridge materials, usually in amounts under $50 paid to individuals rather than businesses. Similarly, the Hutchinson County Commission records during the 1880s list payments from its bridge fund for lumber, bolts, nails, and labor. Rarely did

Old and new technologies meet on a South Dakota road, early 20th century.

the small bridges built through these efforts last more than a few years, either collapsing under a heavy load or washing away during spring floods. In 1881 the Minnehaha County Commission appointed an individual "to hunt up and protect all remnants of county bridges carried away by the spring freshets." In the spring of 1887, the Hutchinson County commissioners authorized the road supervisors to pay people who had salvaged material from bridges washed out by the spring floods.

During the 1870s, Minnehaha county appears to have constructed only three major bridges: the Eighth Street Bridge across the Big Sioux River in Sioux Falls (1876), the Tenth Street Bridge over the Big Sioux (1878), and a bridge over the Big Sioux at Dell Rapids (1879). None of these bridges proved to be substantial structures, and both the Eighth and Tenth Street bridges were rebuilt in 1882. The sporadic bridge-building activity of the 1870s became more systematic in early 1881 when the Minnehaha County commissioners presented a referendum to the voters to build thirteen bridges financed by a $20,000 bond to be backed by the bridge levy. Hutchinson County, on the other hand, was not faced with a major river dividing its center of population, nor with an urban center focused on attracting markets from the west. Consequently, the county did not begin its major bridge construction projects until the late 1890s.



3

IT BEGAN WITH THE RAILROADS

South Dakota's railroad era began in 1868 when the Sioux City and Pacific reached Sioux City, Iowa, from the east. While Yankton businessmen organized to have an extension of the line built west from Sioux City, another railroad was actually the first to penetrate into South Dakota. In order to preserve its land grant, the Winona and St. Peter division of the Chicago & North Western Railroad constructed tracks into the unsettled area around Gary in 1872 and on to the Big Sioux River in 1873. Except for the inaugural train carrying official delegates, this line did not operate until 1878. The Dakota Southern connected Sioux City and Vermillion in 1872 and was completed to Yankton the next year, becoming the first railroad to establish operations in South Dakota. Its completion was made possible only with local aid provided in the form of bonds voted by Yankton and Union counties.

Rail construction in Dakota was effectively halted by the Panic of 1873, and it was not until the economic depression of the 1870s came to an end did South Dakota attract the interest of major railroads. The Chicago & North Western, with the vision of promoting settlement on the South Dakota prairies, and the rival Chicago, Milwaukee, & St. Paul, needing to insure its position as a viable competitor, began planning expansions into South Dakota in 1877. Both railroads reached the Missouri River in 1880, the Chicago & North Western at Pierre and the Chicago, Milwaukee & St. Paul at Chamberlain. Both communities immediately became important shipping points for passengers and traffic destined for the trans-Missouri region. Extension of these lines across the Missouri River, however, was delayed until 1907 by Indian rights on the Great Sioux Reservation. Western South Dakota first received railway service in 1886, with the arrival of a northerly extension of the Fremont, Elkhorn & Missouri Valley Railroad (later absorbed by the Chicago & North Western) from Chadron, Nebraska, to Buffalo Gap.

Besides building rail lines, bridges, and support facilities making the land accessible for agricultural settlement, railroad companies encouraged town settlement and economic development. In 1878, settlers began pouring into South Dakota largely attracted by the cheap, expeditious, and reliable transportation provided by the railroads. Demographic figures between 1870 and 1890 depict the tremendous growth that occurred during the "Great Dakota Boom": the population of what was to become South Dakota increased from 11,776 to 328,808; the number of farms increased from 1,700 to 50,158; and the number of platted towns increased from six to 310.

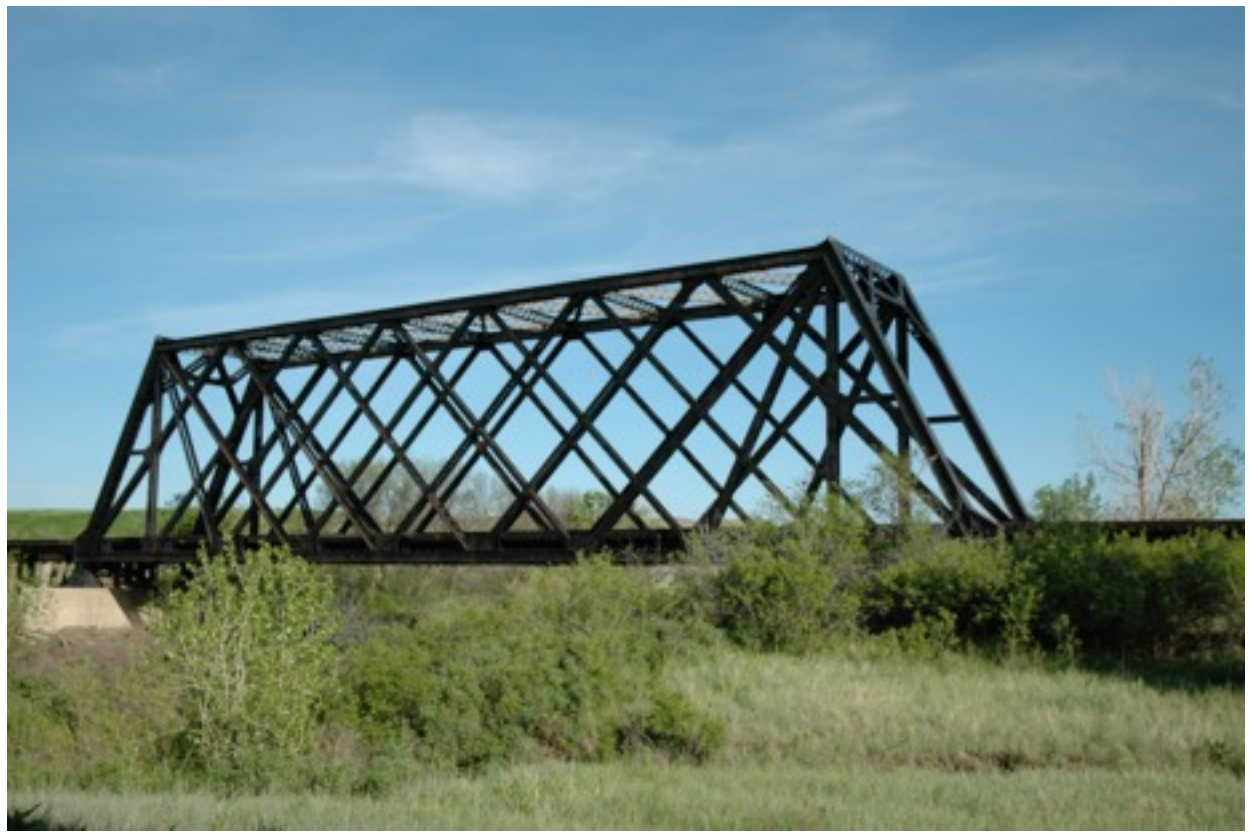
Distinct departments and subsidiaries of railroads – such as townsite companies and farm extension services sought to create new traffic by bringing farmers, merchants, and manufacturers to places along their tracks. Of the 285 towns platted in South Dakota between 1878 and 1890, 228 were established along existing or proposed rail lines and 138 of these were platted by the railroad companies. The market and banking centers along rail lines depended on networks of rural roads in the surrounding countryside to connect them to individual customers and the railroads to connect them to major wholesale and manufacturing centers. Roads and rails worked together to establish an integrated transportation system of trunks, major branches, and smaller feeders. In this way, railroads and their efficient trunk and branch service helped create the need for better roads and new bridges to make that portion of the system function smoothly. This relationship between railroads and vehicular roads continued into the 20th century as railroad companies supported the "Good

Previous page: the Chicago & North Western Railway bridge across the Missouri River at Pierre, constructed in 1909.

Roads" movement, believing it would bring more traffic to their stations and freight yards.

Roads and railroads functioned together in an integrated statewide transportation system of trunks, major branches, and smaller feeders. The efficient transportation provided by railroad trunk and branch lines helped stimulate the improvement of the vehicular roads (and their accompanying bridges) that served the railroad lines. Such improvement was necessary to make the entire transportation system function smoothly. This relationship between railroads and vehicular roads continued into the twentieth century as railroad companies supported the "Good Roads" movement, believing it would bring more traffic to their stations and freight yards. In the words of a North Dakotan writing in 1917, "Just as the railways are classified as the arteries of commerce, so may highways be spoken of as its capillaries."

The railroads themselves built numerous bridges in South Dakota, including some of the largest and most impressive spans in the state. Almost all, however, are beyond the scope of this volume, which is limited to bridges carrying or crossing public roads. Nevertheless, railroads had a significant influence on the evolution of highway bridge construction in South Dakota. Besides creating the need for bridges, the railroad companies helped pioneer the engineering of bridge building with the development of new bridge types and new construction techniques, which were then adapted for highway bridges. Railroads provided the network for economically transporting steel for bridges from industrial centers to the



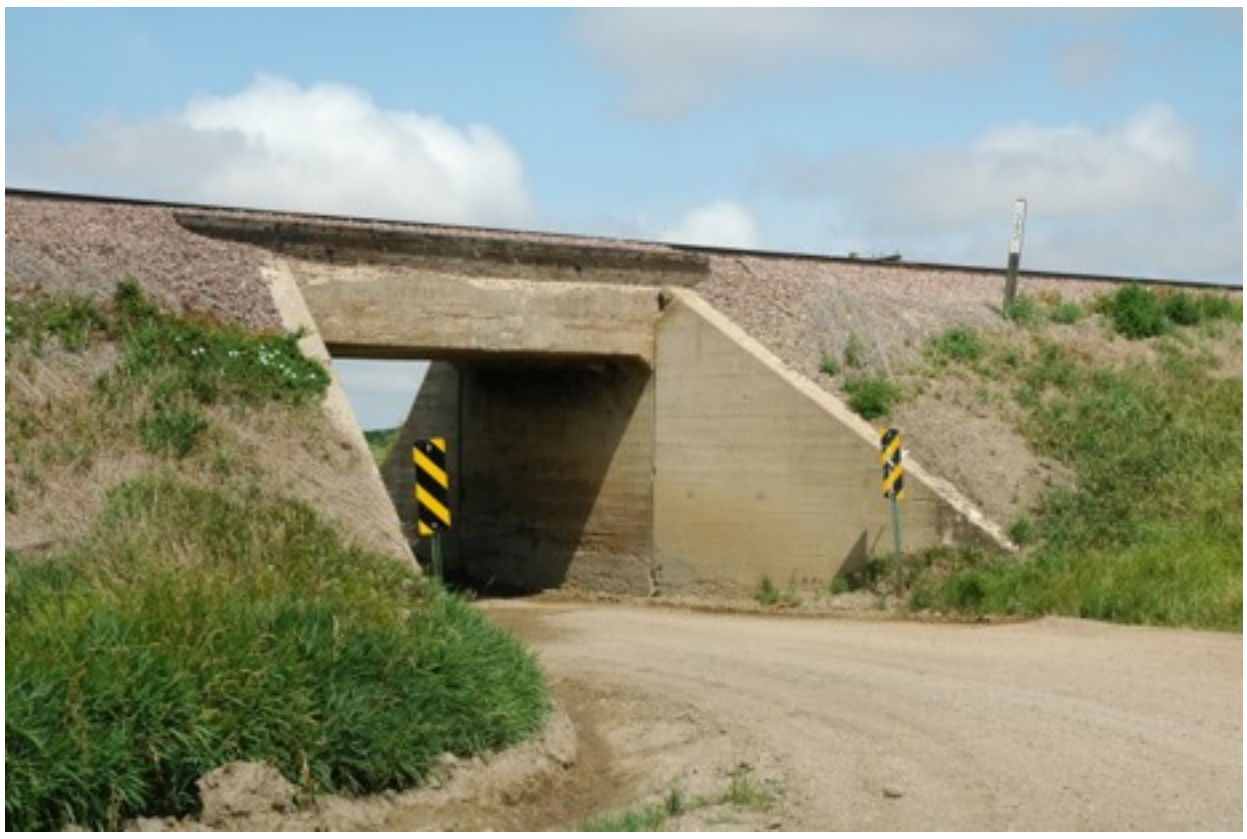
A multiple-intersection through truss bridges on the former Chicago & North Western line between Pierre and Rapid City -- one of the state's most distinctive bridge forms.

state, and railroad bridge engineers pioneered the designs for bridges capable of carrying heavy loads moving at high speeds.

The railroad companies did erect some highway bridges, as well, primarily overpasses and underpasses for city streets crossing rail lines. Occasionally, rural county roads crossed rail lines on railroad-built wooden roadway trestles. These railroad-constructed highway bridges were relatively uncommon; some were built as a part of a track construction project when a new railroad line crossed a roadway alignment, and others were constructed in response to local pressure from city or county governments. Such structures were somewhat more common in western South Dakota, where the uneven topography was more conducive to such designs. The most prominent surviving example, however, is in the community of Big Stone City, where a large railway-built trestle carries a city over a Milwaukee Road line.

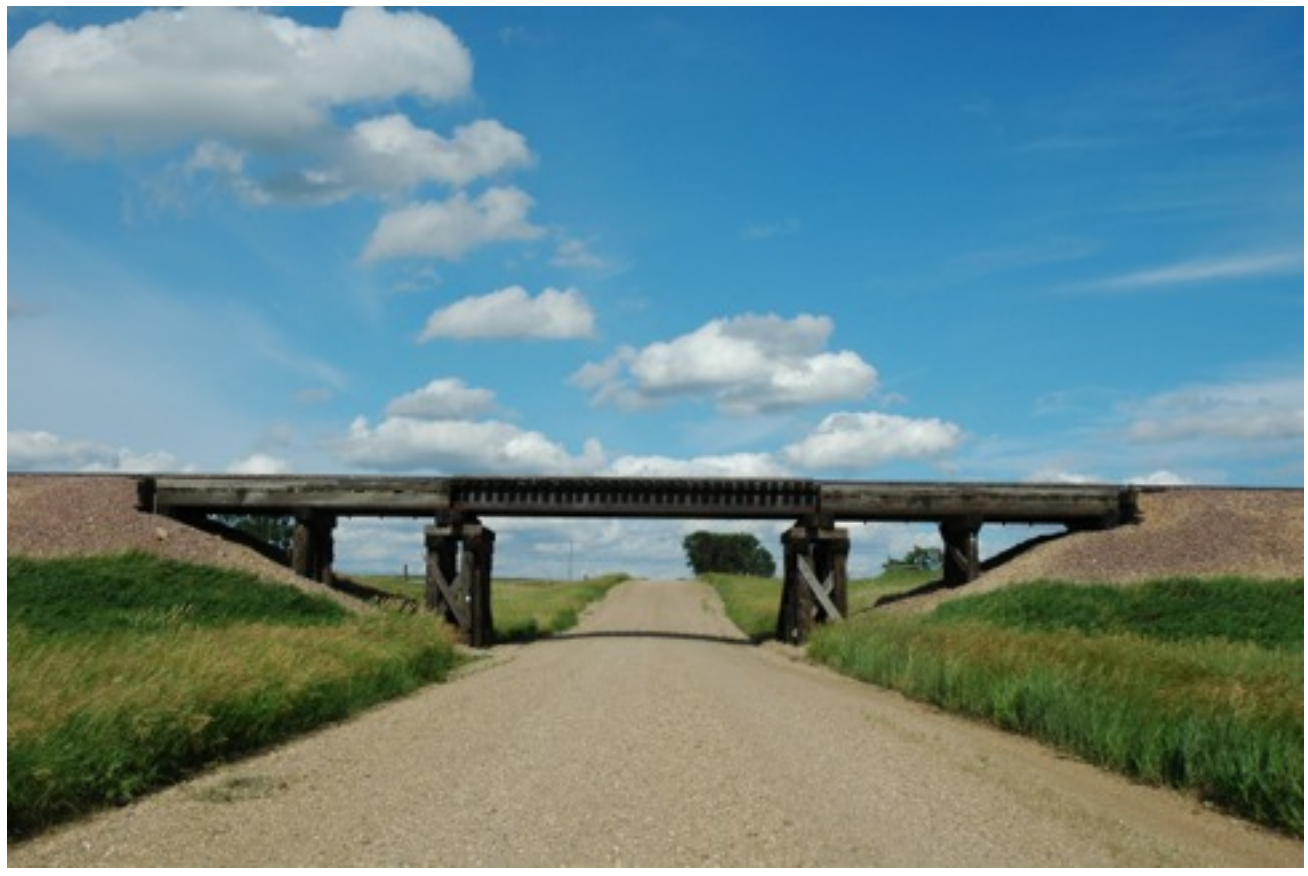
Railroad bridges also occasionally received ad hoc use as vehicular crossings, especially during the early days of roadway construction. Most vehicular uses of railroad bridges were temporary and informal, unsanctioned by either railroad or governmental authorities. One of the states most significant historic bridges, however – the Meridian Bridge across the Missouri River at Yankton – was designed and constructed specifically to accommodate both vehicular and railroad traffic. The planned railway line across the bridge, however, was never built.

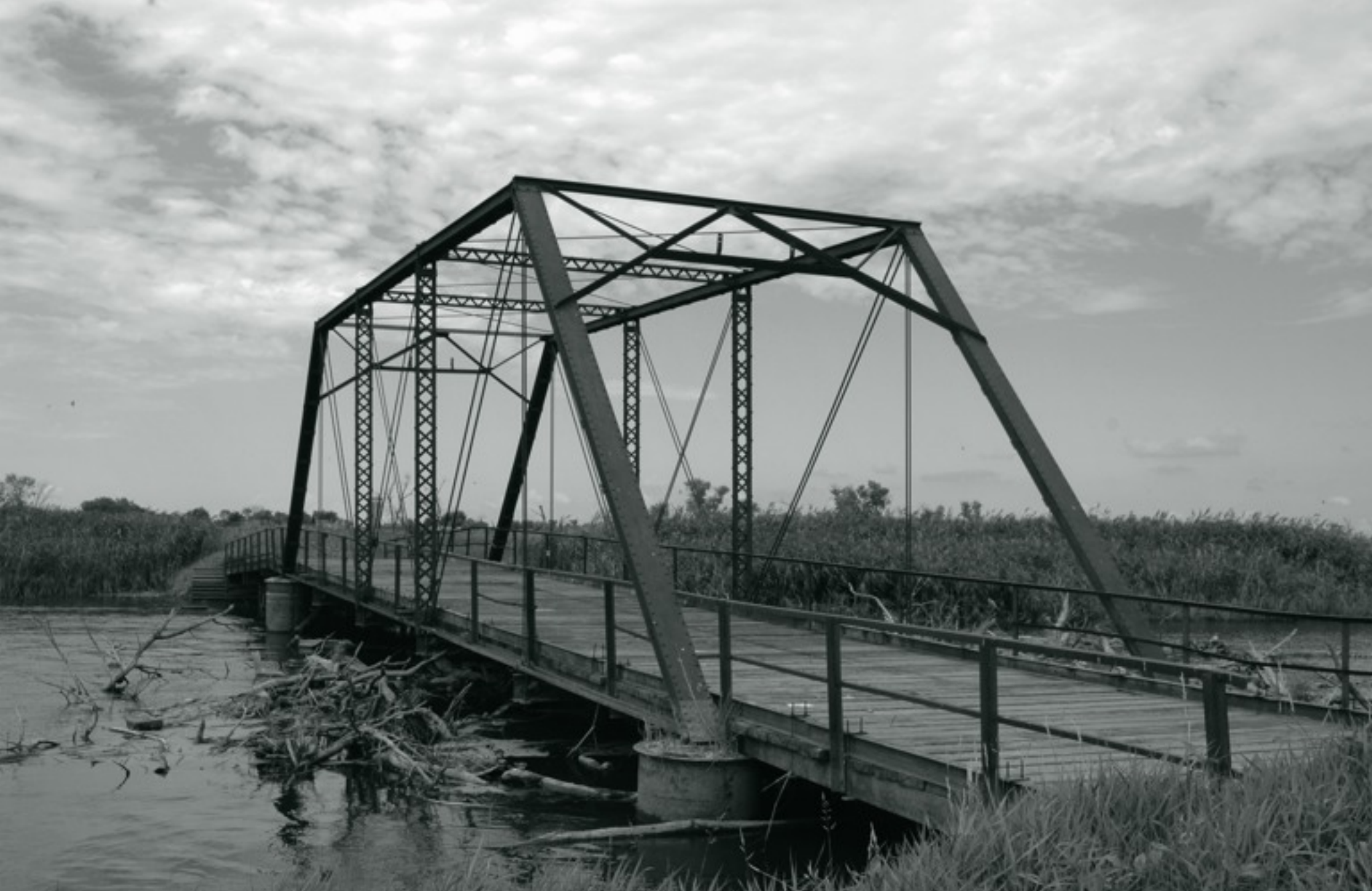
The railroads' dominant role in South Dakota transportation began to decline immediately after World War I. The popularity and availability of motor vehicles resulted in diminishing local rail passenger and freight



A railway-constructed road underpass, on the former Milwaukee Road in northeastern South Dakota.

business in the 1920s. In the following decades, railways began to cut services and eventually dismantle tracks. Through the rest of the twentieth century, increasingly effective competition from other transportation modes caused railways to cut services and abandon tracks, while technological changes enabled the railroads to carry the remaining traffic with a reduced infrastructure. The railroads remain a significant transportation carrier in South Dakota, however, and their legacy is still apparent in the location of towns and related road systems throughout the state.





4

THE TRUSS BRIDGE ERA

In the 1860s and 1870s, several national bridge-building companies gained their reputations by adapting wrought iron for use in comprising bridge superstructures. Their new bridge designs followed two trends of engineering and industrial development. The first involved the designing and patenting of efficient and reliable trusses, primarily of wood, but also of wood and iron (the latter used for tension members). Several nineteenth-century engineers developed trusses that were used in a variety of applications, usually experimental and limited. The three most important patents were the Howe truss (William Howe, 1840), which consisted of diagonal members in compression and vertical members in tension; the Pratt truss (Thomas and Caleb Pratt, 1844), comprised of vertical members in compression and vertical members in tension; and the Warren truss (developed in the United States by Squire Whipple in

1849 without the knowledge of James Warren's invention of James Warren's invention of the same truss in England the year before), which used diagonals in both tension and compression. In the mid-nineteenth century, the Howe truss was the most commonly used wood truss; by the late nineteenth century, when iron and steel replaced wood for longer spans, the Pratt became the most widely used truss. In the twentieth century, after the riveted connection replaced the pin-connection as standard practice, the Warren truss became more frequently used for steel bridges. The Warren's first wide use was for pony trusses. It later received extensive use for the longer spans, previously served by the Pratt through truss, as well.

The Pratt was the type most commonly used for South Dakota's metal-truss bridges until about 1910. From then until the formation of the State Highway Commission, the Warren truss became more widely used for smaller truss bridges. There were exceptions to the Pratt, however, such as an unusual 1894 hybrid of the Pratt and Warren configurations built in Hamlin County (no longer extant) by the King Bridge Co.

At about the same time as engineers were experimenting with various truss configurations, others were attempting to employ iron for bridges. Two types of iron, cast and wrought, were used in bridges. Cast iron contains more carbon than does steel and includes other impurities. As its name implies, it is usually cast into required shapes; its brittleness makes it unsuitable for forging and rolling. The collapse of the Ashtabula Bridge in Ohio in 1876 ended the use of cast iron in bridges.

Wrought iron is nearly pure, containing only a tiny amount of slag. It can be easily worked and is used for forging and in blacksmith work. In the mid-19th century, mills rolled wrought iron to produce structural shapes such as I-beams, channels, angle sections, and plates. The Keystone Bridge Company of Pittsburgh was one of the first to use wrought iron for all members of its bridge trusses. The Phoenix Iron Company of Phoenixville, Pennsylvania developed a tubular girder of wrought iron shapes, which was excellent in compression, shear, and bending. In the 1860s, several engineers, such as Zenas King of Cleveland, Ohio, and David Hammond of the Wrought Iron Bridge Company of Canton, Ohio, developed tubular arch, or bowstring arch, truss bridges, all generally derived from the masonry arch. King's tubular arch was rectangular in section, while Hammond employed the Phoenix tubular girder, which was circular in section. Bowstring arch bridges suffered from a number of technical problems, however, and by the close of the 1870s their use largely ended. Although a few bowstring arch bridges are extant nationally, none survive in South Dakota.

Previous page: an early twentieth century Pratt through truss bridge, in Brown County.

By the early 1890s, wrought iron had become the standard structural type for long-span bridges in South Dakota. For example, in May 1890, the Minnehaha County Commissioner received bids for the Tenth Street Bridge and Viaduct. The plans called for the bridge to be "two spans of wrought iron trusses" and the viaduct to have "a sub-structure of wrought iron columns and cross beams."

After the Civil War, the adoption of the Bessemer converter made possible the production of large amounts of steel at low cost. Yet, bridge builders used Bessemer steel in only limited quantities. Not until large-scale open-hearth steel production began in the 1890s did steel become the preferred material for structural members in truss bridges. Wrought iron virtual1y disappeared from bridge work in the mid-1890s and by 1894, virtually all bridges in the United states were being built of steel. Thus, all or virtually all of South Dakota's surviving metal truss bridges are fabricated of steel.

Shippers and Fabricators

The erection of iron and steel bridges was preceded by two distinct manufacturing processes – the reduction and rolling of the metal and its fabrication into members appropriate for bridge assembly.

Bridge iron came from foundries and rolling mills. After reduction of the combined iron ore, coke, and limestone (flux) in blast furnaces, the resulting pig iron could be re-melted and poured into molds to create cast iron shapes. To make wrought iron, puddlers stirred the molten pig iron to remove impurities before casting it into ingots. The product was then sent to a forge shop or rolling mill, where it was worked into the required shapes.

The process of making steel begins like iron, with ore, fuel, and flux melted in blast furnaces at steel mills. The resulting pig iron became steel in open-hearth furnaces with the introduction of calcium and other alloys. As with iron, rolling mills produce steel I-beams, channel and angle sections, plates, bars, and other structural pieces. The steel used in bridges recorded in this survey came from throughout the main steel-producing belt of the nation, Pennsylvania and the states next to the Great lakes. I-beams and channel sections marked "ILLINOIS" (South Chicago), "CARNEGIE" (Pittsburgh), and "CAMBRIA" (Johnstown, Pennsylvania) were most commonly observed in the superstructures of South Dakota’s historic bridges. Less frequently seen were products of Inland, Jones & Laughlin,

Lackawanna, Bethlehem, and Scullin. South Dakota bridges often include steel from two or more mills.

Fabricators bought standard lengths and sizes of rolled steel products and fashioned them into bridge parts. Their plants were large industrial complexes which housed several distinct functions. After receiving an order for a bridge, clerical staff arranged contractual and shipping details while the engineering department prepared detailed plans, lists, and instructions for fabrication and erection. The template shop made or used already existing wood patterns to guide workers in the riveting shop, who cut, punched, and bored the steel. Fabricators also did as much assembly as was possible, riveting together chord members, struts, and other built-up sections before transporting them to the bridge site for completion. For pin-connected bridges, two other departments were also important. The machine shop turned the pins, as well as doing other planing and finishing. The forge shop produced eye-bars and other items requiring foundry and blacksmith work.

No truss bridge fabrication is documented as having occurred in South Dakota. The 1900 census reported thirteen foundries and machine shops in the state producing articles for local consumption, such as window weights, pump castings, architectural iron work, stove parts, and plow bottoms. The largest 19th century foundry appears to have been in Rapid City, specializing in drills and windmills, although the plant also cast stamps, dies, and gears. None of the South Dakota foundries or machine shops engaged in the production of structure steel or iron work.

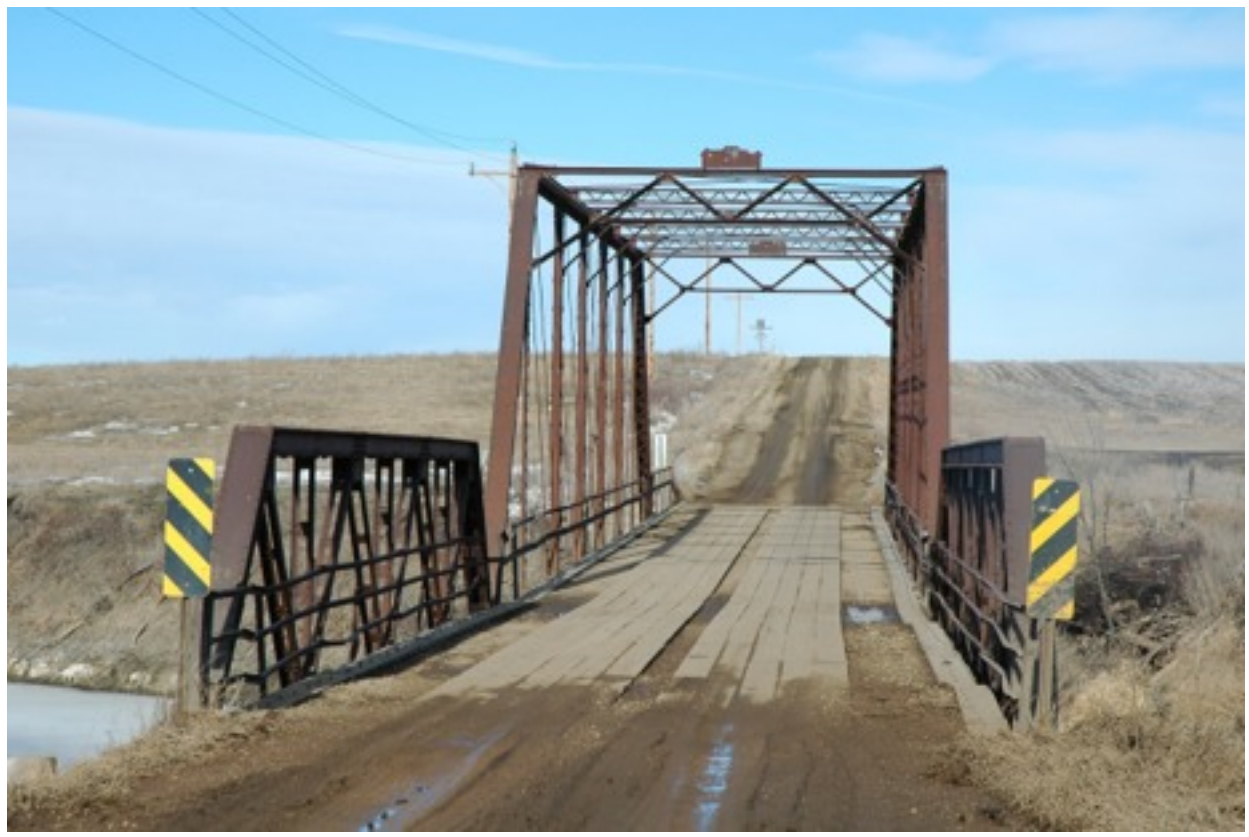
Because there were no in-state fabricators of iron or steel bridges, South Dakota counties had to rely on out-of-state firms, who transported bridge materials to the state by railroad. Out-of-state fabricators that are known to have built bridges during the late 19th century in South Dakota include: Wisconsin Bridge and Iron Company of Milwaukee, which built bridges in Minnehaha, Spink, and Hamlin counties; the King Iron Bridge Company of Cleveland, Ohio, which built bridges in Minnehaha and Hamlin counties; the Gillette-Herzog Manufacturing Company of Minneapolis, which built bridges in Brown and Moody counties; the Wrought Iron Bridge Company of Canton, Ohio, which built bridges in Beadle and Spink counties; the Canton Bridge Company of Canton, which built bridges in Turner County, and would continue to be active in several other counties in the early 20th century; the Milwaukee Bridge and Iron Works, which built bridges in Minnehaha and Spink counties; the western Bridge Company of Chicago, which built bridges in Beadle and Turner counties; the Clinton Bridge Company of Clinton, Iowa, which built bridges in Hamlin County, and the Chicago Bridge and Iron Works, which built bridges in Spink County. These and other out-of-state bridge fabricators were also active

bidding in these and other South Dakota counties during the 19th century. Nearly all of the bridges built by these firms have since been replaced.

19th Century Bridge Designs

As the counties began building larger bridges to span South Dakota's major rivers, county commissioners found themselves needing to rely on individuals with some expertise in engineering and construction. In 1890, plans for the Tenth Street Bridge and Viaduct in Sioux Falls were prepared by J.F. Jackson who was apparently the City Engineer. And, occasionally the county commissioners retained an engineer to prepare bridge plans. For example, in 1897, Minnehaha County paid S.B. Howe, a civil engineer, $166.20 for plans and specifications for a two-span 120-foot stone bridge. In most instances, however, the county commissioners relied on the bridge companies to provide their own plans and specifications. At bid openings, agents representing the competing bridge companies would argue the merits of their particular designs before the commissioners. The commissioners "had no engineering advice and the choice was purely an uninformed arbitrary selection."

From the early 1890s, South Dakota counties followed the general national trend of using metal-truss bridges mostly for long spans, and sometimes for short spans as well. As was true throughout the nation in the 1890s, most of South Dakota's early metal truss bridges were pin-connected Pratt through trusses. The "pin-connected" part of this descrip-



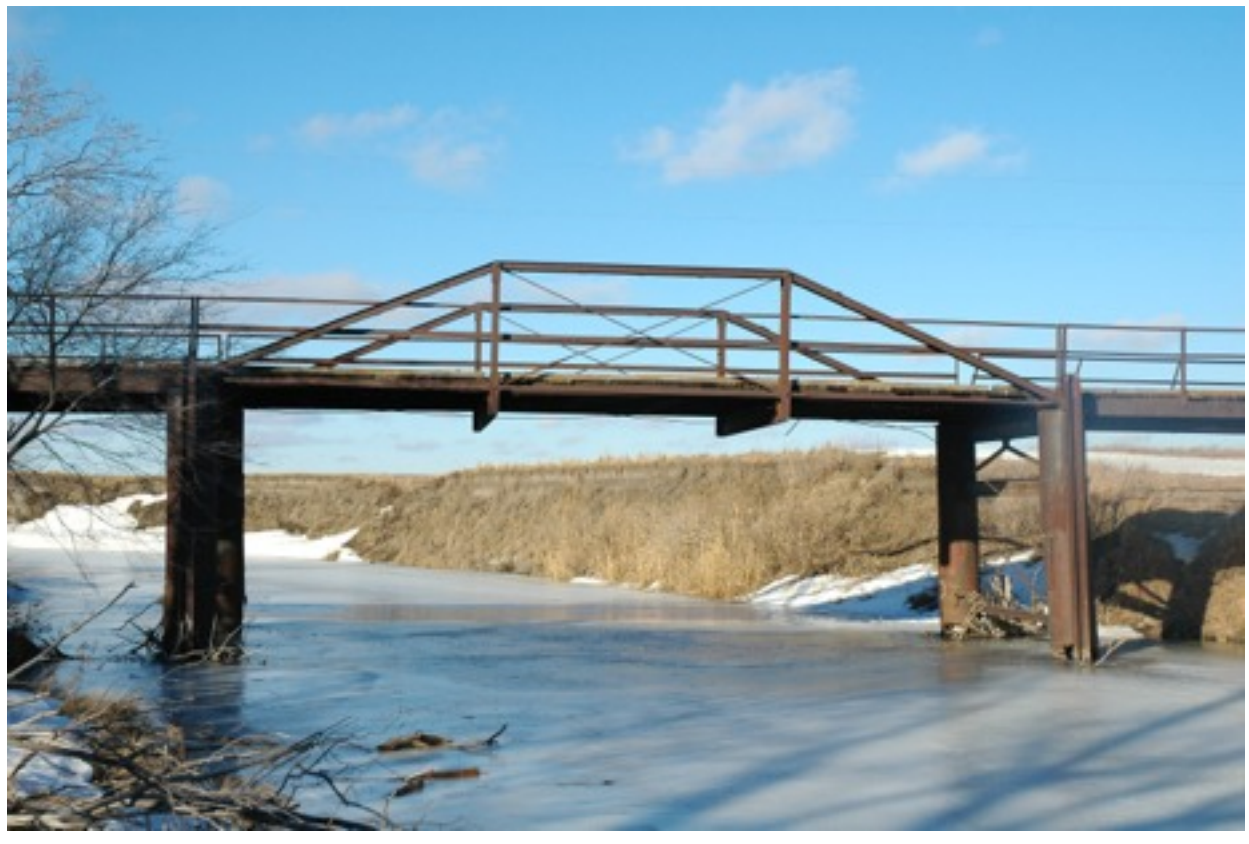
An example of an early pin-connected Pratt through truss bridge, with builders plates centered above the portals. The smaller span in the foreground is a Warren pony truss, of newer design.

tive name for the truss type means that all of the members of the truss are connected with large pins rather than being riveted.

To call one of these early bridges a through truss means that the deck, or the roadway of the bridge passes through, or between, the trusses, rather than resting on the top chord, in which case it would be called a deck truss. Through trusses also have overhead bracing to resist horizontal wind loads. Although generally used for spans of more than 100 feet, some through trusses with spans as short as 70 feet survive in South Dakota.

Deck trusses, which have the roadway connected to the superstructure along the upper chords, were rarely used in South Dakota because they are better suited to crossings where the roadway is high above the river bottom. No 19th century deck trusses survive in South Dakota, but there are two early 20th century deck trusses: the Chilson Bridge built in 1929 over a now-abandoned railroad line in Fall River County, and the Cheyenne River Bridge near Wasta, built in 1940.

Pony trusses are similar to through trusses, because the roadway is connected along the lower chords, but they differ by the absence of overhead bracing. Pony trusses are short enough that the trusses do not extend very high above the deck. Therefore, bracing against lateral loading is either not needed or may be accomplished with diagonal bracing along the outer sides of the trusses. Pony trusses were generally used for spans of less than 80 feet. During the early years of the transition from wood to steel, counties used metal through truss bridges for longer spans and continued to use wood for shorter spans. Few metal pony trusses were built in



A small pin-connected Pratt pony truss bridge from the early twentieth century, with historic steel-caisson piers and steel stringer approaches.

the 19th century, though they became a common bridge form in the early 20th.

19th Century Bridge Builders

Although 19th century fabricators built many of their own bridges, there were some contractors in the region who only built bridges, purchasing their iron and steel from fabricators. Among those active in South Dakota were George E. King and Company of Des Moines, George E. Wise and Company of Council Bluffs, N.M. Stark and Company of Des Moines, C.P. Jones and his Minneapolis Bridge Company (later Minneapolis Bridge and Iron), S.M. Hewett (later the Hewett Bridge Company) of Minneapolis, and J.G. Bullen of Ashton, South Dakota.

Although many local bridge builders in South Dakota built timber bridges during the 19th century, J.G. Bullen is the only one who has also been documented erecting iron or steel bridges. (Ashton is about twelve miles north of Redfield, the county seat of Spink County.) Bullen received several contracts to build bridges in Spink County between 1893 and 1902, though none survive today. N.M. Stark is typical of the out-of-state bridge contractors who generally got their start in the region as agents for bridge-building companies. In Stark's case, after completing studies in engineering at the state Agricultural College at Ames, he worked in Des Moines as an agent for the Kansas City Bridge and Iron Company (late 1880s) and for the King Bridge Company (early 1890s) before founding the N.M. Stark Company, based in Des Moines, in 1898. All of Stark's metal truss bridges were replaced by the end of the 20th Century, though some of the reinforced concrete bridges he built in later years may survive.

Early 20th Century Bridge Building

Around the turn of the 20th century, settlement patterns east of the Missouri River were fairly well established, while the West River region experienced a boom in settlement with new areas opening for homesteading. East of the river, agriculture was becoming more mechanized and, with a well-established network of railroads, the region's dependence on the export of farm products grew. These factors led to an increased demand for reliable bridges. On the one hand, many counties took steps to protect the bridges they had, passing ordinances prohibiting steam traction engines and thrashing machines from crossing some bridges and requiring farmers to protect the decks and stringers of others with additional planks when they moved their heavy equipment across the structures. On the other

hand, the early 20th Century witnessed a tremendous increase in the construction of new or replacement bridges, especially those made of steel.

As early as 1905, the president of the American Society of Civil Engineers was recommending that the "only fair and business-like method" for purchasing bridges was "to let contracts for structural steel work on a pound-price basis, on designs and specifications furnished by an experienced engineer employed by the purchaser." He went on to say:

> *... bridges are frequently designed by incompetent or unscrupulous men, and the contracts are awarded by ignorant county officials, without the advice of a competent engineer. The merit of the design receives generally no consideration, and the contract is awarded in many cases to the one offering the poorest design and making a bid which is satisfactory to the officials, if not the taxpayers.*

Kenneth Scurr, the South Dakota Bridge Engineer from 1931-1963 would later have similar observations:

> *In some cases these [bridge] salesmen did furnish a real service and the counties benefited thereby, while in others the salesmen could not resist the temptation to abuse the confidence placed in them and sold structures without regard to fitness or need but with the idea in mind of using up the entire bridge levy before some other salesman got to the commissioners ...*

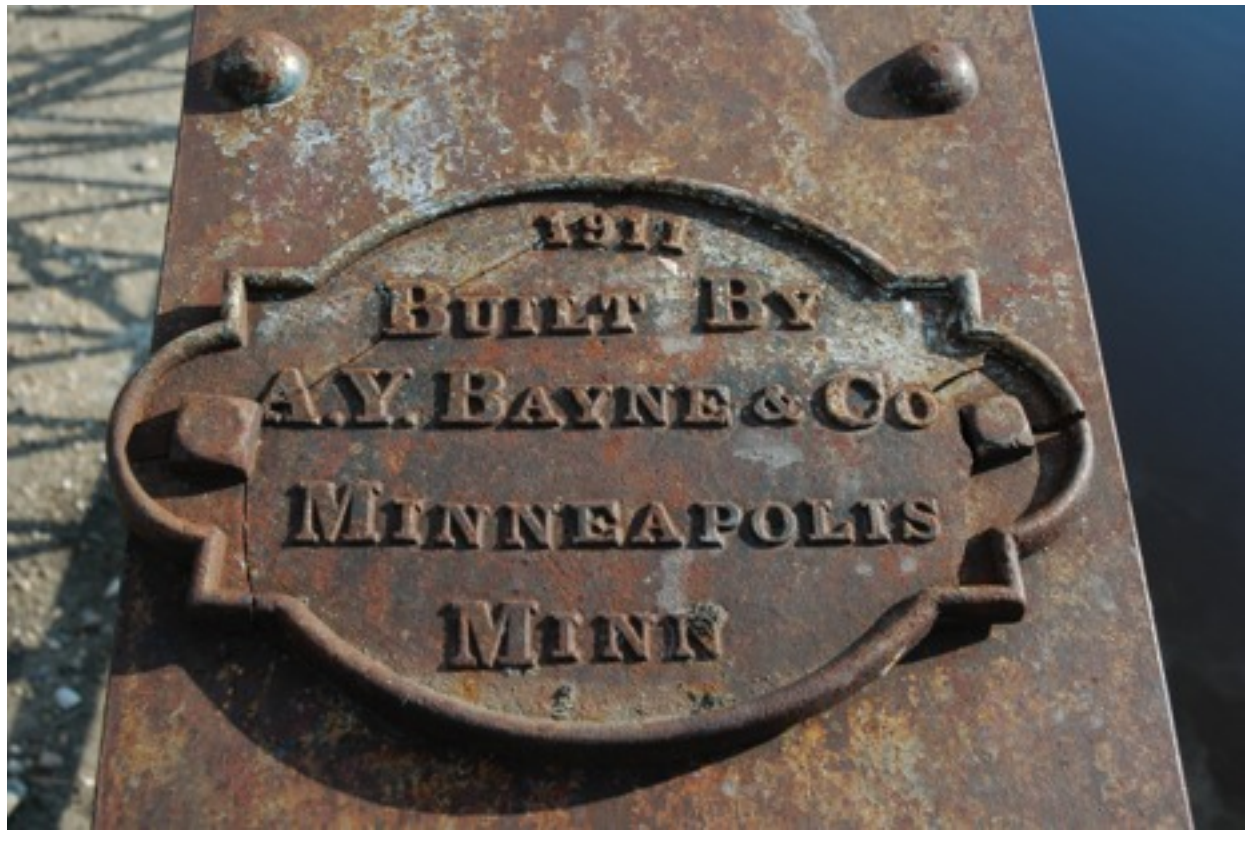
After 1900, the commissioners began adopting plans and specifications from one company on which all builders were required to present bids. In cases of some of the larger counties, the county surveyor had the technical expertise to advise the commissioners in these matters, but in most cases, the commissioners had to select plans and specifications based on their own experience and the advice of the bridge companies. The commissioners themselves continued to determine the location and need for petitioned bridges, usually with on-site visits.

Accompanying the increase in the numbers of bridges erected in South Dakota was a transition in the character of bridge builders in the state. Whereas nineteenth century contractors of steel or iron bridges had generally, but not always, been fabricators as well, in the early twentieth century the balance tipped in favor of firms that erected bridges, but did not fabricate the structural members. With few exceptions, these new contractors were also out-of-state firms.

Minneapolis-based forms maintained some business in South Dakota. After the American Bridge Company absorbed the Gillette-Herzog

Manufacturing Company in 1900, the Minneapolis plant continued to win bridge-building contracts in Brown County, using the name Gillette-Herzog through 1901 and American Bridge Company in 1902. A.Y. Bayne, who had been the manager of the bridge department for Gillette-Herzog, continued in that capacity with American Bridge Company until 1903, when he formed his own A.Y. Bayne and Company, which continued to erect bridges fabricated at American Bridge Company's Minneapolis plant. Bayne's company was the principal bridge contractor in Brown County until 1913, at which time he changed the name of his company to the Minneapolis Bridge Company. A small number of Bayne's truss bridges survive in South Dakota in 2014, the oldest being a 1910 structure over Snake Creek in Brown County, near Aberdeen.

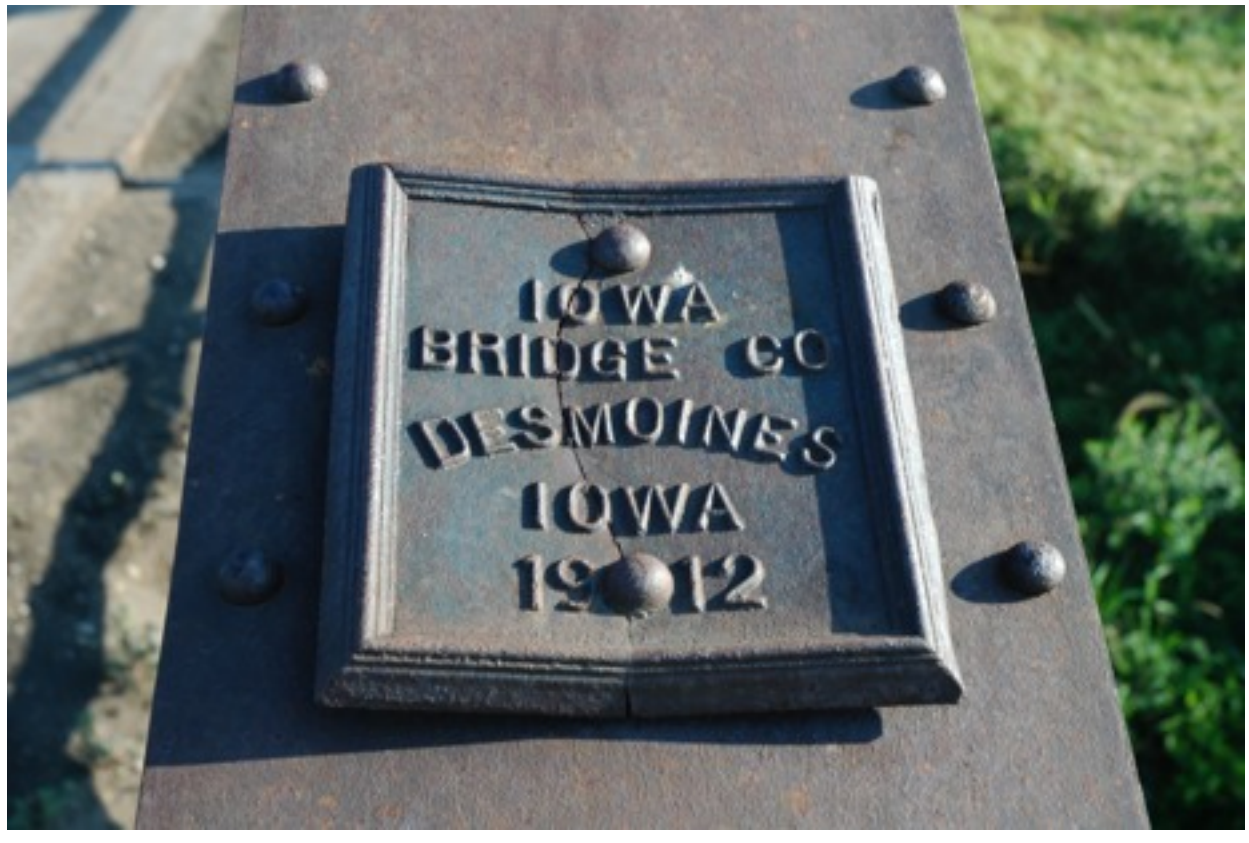
William S. Hewett is another Minneapolis-based contractor who was active in South Dakota in the early 1900s, though none of his bridges endured into the 21st Century. He had started his career in the 1880s with his uncle, S.M. Hewett. In 1896, William began his own William S. Hewett and Company. Like the other bridge builders from Minneapolis, Hewett extended his market area as far west as Montana, and bid on many South Dakota projects. In 1907, William Hewett and his cousin, Arthur L. Hewett formed the Security Bridge Company of Minneapolis, and their new firm continued to be a major regional bridge contractor. The Security Bridge Company's oldest surviving bridge in South Dakota is a 70-foot pin-connected Pratt pony truss, built in 1908 and now spanning an irrigation ditch near Brandt in Deuel County. A handful of the firm's other bridges still survive in central and eastern South Dakota.



The builders plate from an A.Y. Bayne pony truss bridge, in Brown County.

The most active out-of-state bridge building contractors, however, were from Iowa and Nebraska. The Federal Bridge Company and the Iowa Bridge Company of Des Moines and the Standard Bridge Company and the Western Bridge and Construction Company of Omaha each dominated bridge building in several counties during the first two decades of the 20th century. The Iowa Bridge Company was by far the most successful of the four, dominating bridge contracts in Beadle, Bon Homme, Brookings, Clay, Douglas, Hamlin, Hand, Hutchinson, Sanborn , Spink, and Turner counties and winning occasional contracts in Brown, Davison, and Miner counties as well. The company's president was James S. Carpenter, who had been a traveling agent for the N.M. Stark Company of Des Moines in the 1890s. Carpenter started the Iowa Bridge Company in Des Moines in about 1902 and was immediately successful in obtaining annual bridge contracts in counties such as Bon Homme, Brookings, and Sanborn where his former employer had been active. As of 2014, the oldest surviving Iowa Bridge Company structures in South Dakota is the Turtle Creek Bridge, a 60-foot pin-connected Pratt pony truss near Tulare in Spink County. A number of other Iowa Bridge Company spans also survive, in Spink County and elsewhere.

The Federal Bridge Company was another Des Moines bridge-building firm which was especially active in South Dakota. Officers of the company were Edwin S. and Hamilton Carpenter. Hamilton, Edwin, and James Carpenter were apparently related and Hamilton and Edwin had worked for the Iowa Bridge Company before forming Federal. When it suddenly appeared in sooth Dakota in 1911, the Federal Bridge Company was successful in earning annual bridge contracts in such counties as Clay,



The builders plate from an Iowa Bridge Company project in 1912.

Douglas, Hanson, Hutchinson, and Turner. In each county, the Iowa Bridge Company had controlled the annual bridge contracts until the Federal Bridge Company appeared on the scene. The oldest surviving Federal Bridge Company bridges in South Dakota date from 1912.

Both Omaha-based bridge-building firms that were especially active in South Dakota had their origins early in the 20th century. The Standard Bridge Company was organized by Robert Z. Drake in 1900. Drake was born and educated in Kansas and began building bridges in the early 1890s when he was in his early twenties. Besides working as a contractor, he was an innovator developing a configuration of steel pilings for bridge substructures and the transverse joist bridge. He also developed standardized plans for truss bridges that were widely used in Nebraska and elsewhere. The oldest surviving Standard Bridge Company structure in South Dakota is a 60-foot pin-connected half-hip Pratt pony truss (bridge no. 51-051-000) built in 1902 over the Big Sioux River near the Lake Campbell Resort in Moody County. Nearly all of Standard Bridge Company's South Dakota structures were replaced in the late 1900s.

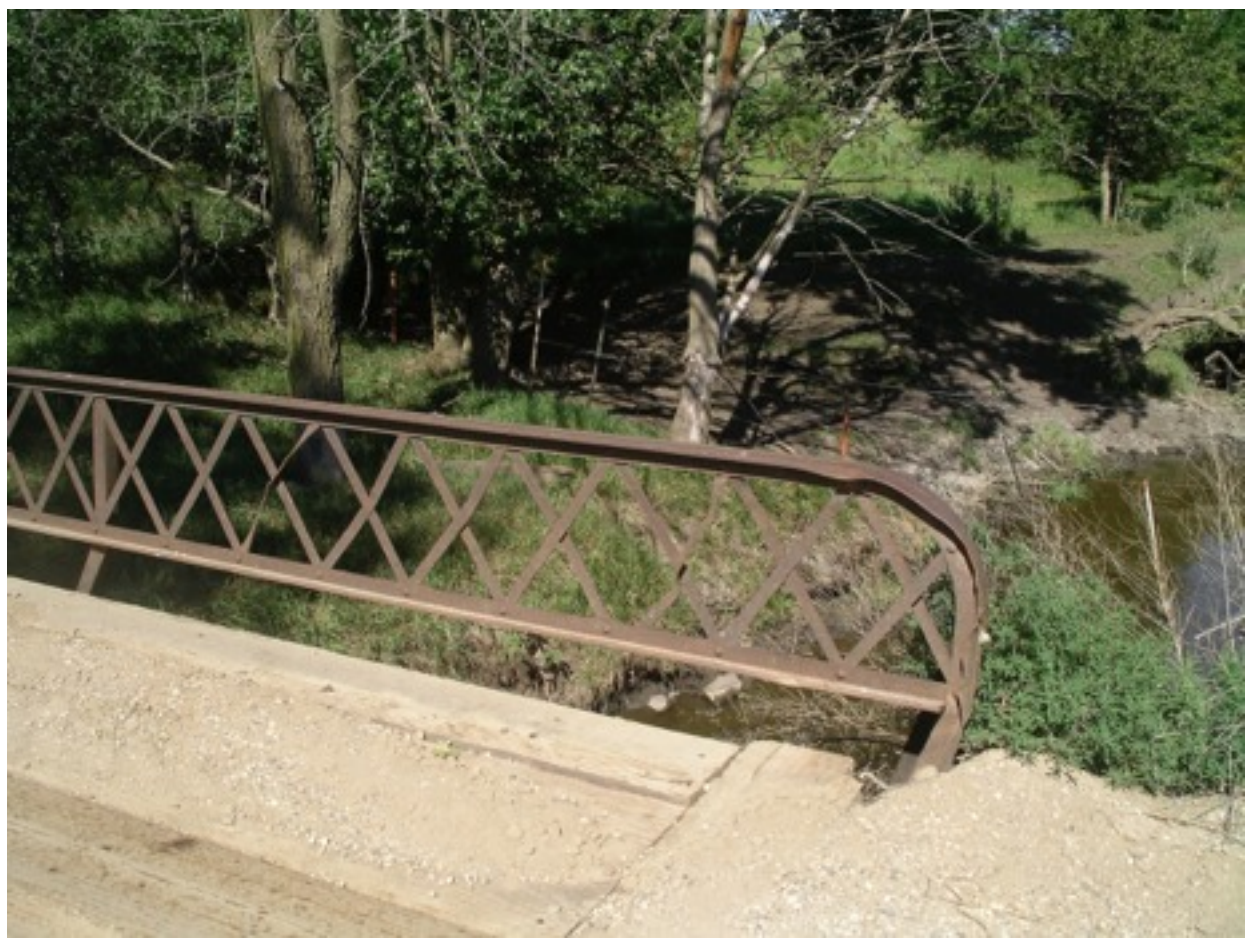
The other major Omaha contractor in South Dakota was the Western Bridge and Construction Company. John W. Towle of Omaha organized the firm in about 1907. A native of Nebraska, Towle received his education in civil engineering at Cornell University and returned to his home state, where he worked in the late 1890s as the general western agent for the Canton Bridge Company. Just after the turn of the 20th century, he started his own bridge-building company, which by 1907 was known as the Western Bridge and Construction Company. Again, most of Western's South Dakota bridges have now been replaced, though a handful survuve in the western part of the state.

One out-of-state fabricator/builder, the Canton Bridge Company of Canton, Ohio, continued to be active in South Dakota well after the turn of the 20th century. Incorporated in 1891, the firm was active in its own state as well as in the trans-Mississippi west. Agents based in Omaha conducted the company's bidding and supervised the company's bridge construction in South Dakota. John Towle had been the Canton Bridge Company's Omaha agent in the 1890s, and early 20th century agents included Mort J. Underwood and Fred R. Hoover. The company had been active as early as 1897 in Bon Homme and Turner counties. In the 20th century, the Canton firm was successfully bidding on annual contracts in Butte, Harding, and Perkins Counties, as well as receiving occasional contracts in Aurora, Sully, and other counties. The oldest surviving bridges built by the Canton Bridge Company date to 1906, when the firm received a contract from the U.S. Reclamation Service to erect spans over the diversion ditch of the Belle Fourche Irrigation Project. That same year, the Butte County Com-

missioners awarded a contract to the Canton Bridge Company to build five bridges, of which only the 140-foot pin-connected Pratt through truss Vale Bridge survives.

South Dakota Bridge Builders, 1900-1920

Although out-of-state firms captured the largest share of early-20th-century bridge-construction projects in South Dakota, there is one notable exception. Fred Bjodstrup of Mitchell maintained a competitive posture relative to out-of-state firms for nearly two decades, eventually being succeeded in 1912 by the Pioneer Bridge Company, managed by his son, Arthur Bjodstrup. Born in Denmark in 1857, Bjodstrup emigrated to the United states in 1876 and moved to South Dakota in 1882. Two years later he moved to Mitchell, where he established a construction business. As early as 1886, he was building bridges in Minnehaha County in partnership with F.P. George, an early Dakota bridge builder based in Parker, South Dakota. Bjodstrup was the principal bridge builder in Davison County from the early 1890s through 1911, and erected bridges in Miner and Aurora counties in the 1900s while bidding as well in Brown, Hamlin, Sanborn, and other counties. In addition to building bridges, Bjodstrup constructed commercial and other buildings in the Mitchell area. He ceased bidding on projects in 1912 after his son Arthur founded the Pioneer Bridge Company, which continued to receive annual contracts in Davison and Miner Counties. Fred Bjodstrup continued working with his son until the early 1920s, when deafness forced him to retire. No bridges built by Bjodstrup prior to



The distinctive lattice guard railing from an early South Dakota bridge project.

the formation of the Pioneer Bridge Company are known to survive in 2014, although a small number of Pioneer Bridge Company structures do.

Another active early-20th-century bridge-building firm in South Dakota was J .A. Crane and Sons, based in Centerville. Little is known of Crane or his company, other than the fact that he began bidding on bridges in Turner County as early as 1894. Between 1900 and 1905, he was successfully bidding on projects in Turner County, receiving several contracts during that period. Crane was also the successful bidder during several years in Clay County during the early 1900s and bid on projects in Nebraska as well. The last surviving bridge built by Crane's firm was replaced in 2007.

Michael Gales of Aurora County represents a different category of local bridge builders in South Dakota. Unlike the Bjodstrups and the Cranes, who actively bid on bridge projects outside their home counties, Gales apparently bid only on bridge work in Aurora County. Michael Gales was born in Germany in 1865 and emigrated with his parents to the United States in 1878. The family homesteaded in what would became Gales Township, Aurora County, in 1882. Besides farming several hundred acres of land, Gales operated a hardware and implement store in Plankinton and built bridges during the 1910s and 1920s. He first bid on bridge projects in Aurora County in 1908 and won his first bridge contract in 1911. The following year, when the County adopted the system of awarding annual contracts in response to a new state law, Gales won the annual contract and continued to build bridges in the county through the end of the decade. All have since been replaced.

Other South Dakotans in related businesses also tried their hands at truss-bridge construction. One example is Clarence E. Gilbert, who moved to Aberdeen in about 1911 to manage the Gilbert Improved Corrugated Culvert Company, which manufactured a patented steel culvert at Aberdeen and Austin, Minnesota. By 1913, Gilbert was president of the Gilbert Manufacturing Company, which soon became one of the largest employers in Aberdeen, manufacturing road construction equipment in addition to being a sheet metal works. Many counties in South Dakota purchased their steel culverts from Gilbert. In 1912, Gilbert briefly entered the bridge construction business in Brown County after the county commissioners had rejected earlier bids for four bridges, believing them to be too high. Gilbert submitted a bid in the second round and underbid A. Y. Bayne, who had been receiving bridge contracts in the county on a regular basis. One of Gilbert's four bridges survives in 2014, spanning the James River near Hecla. The 1912 projects are the only bridge work for which Gilbert entered a bid, although he did continue to bid on supplying culverts to Brown and other counties.

Perhaps because it was a major transportation hub for the Milwaukee Road and the Chicago & North Western Railroad, several other individuals, in succession, attempted to establish bridge-building companies at Aberdeen. One of the first was W.C. Kiernan and Company, Earl C. Knilans manager, which began bidding on Brown County projects in 1910 and in such counties as Beadle and Turner within a few years. William Kiernan lived and his company was based in Whitewater, Wisconsin. In about 1914, Earl Knilans moved to Whitewater and with Marcus Knilans established the Whitewater Bridge Company, which had an office in Aberdeen managed by Archie J. LaLonde. LaLonde had earlier been the manager of Swift and Son in Aberdeen. The Whitewater Bridge Company first began bidding on Brown County bridge projects in 1914, and won a contract to repair a bridge. Later that year, the commissioners adopted the company's bridge plans and specifications, but it lost the bidding for the annual bridge contract to the Iowa Bridge Company. Nevertheless, the Whitewater Bridge Company was successful in winning the annual bridge contract for 1917, plus a special contract to build a bridge (no longer extant) at Tacoma Park. The Whitewater Bridge Company's Aberdeen office bid on projects elsewhere, even as far away as Walsh County, North Dakota.

In about 1919, the Whitewater Bridge company closed its Aberdeen office and Archie LaLonde, in partnership with Glen R. Martin, formed the Aberdeen Construction Company. Prior to joining LaLonde in business, Martin had been an insurance agent with an office next door to that of the Whitewater Bridge Company. The fact that LaLonde and Martin had little actual practical experience in bridge building represented a characteristic that distinguished some 20th century bridge builders from their predeces-

Floodwaters threaten an unidentified nineteenth-century South Dakota bridge.

sors, who generally had hands-on experience if not a formal education in civil engineering. Many bridge-building concerns were headed by businessmen who acted as agents for the fabricators, conducted the bidding and signed the contracts, and then hired knowledgeable foremen to supervise the actual construction work. The new Aberdeen Construction Company won its first contract to construct bridges in Brown County in 1919. In 1920, the firm was low bidder for six small I-beam bridges, and in 1921, received the contract for the county's road work, bridges, and culverts even though not the low bidder. One of the company's truss bridges survives in 2014, southeast of Stratford in Brown County.

Stone-Arch Bridges

Although fairly common in some parts of the United States, stone-arch bridges were not widely built in South Dakota. One early stone-arch bridge in Minnehaha County, built in 1897, must have been quite substantial. The bridge consisted of two 60-foot arch spans and, as already noted, the commissioners hired a civil engineer to design it. Several small stone-arch bridges were built in Deuel County in the early 20th century. Turner County built numerous stone-arch bridges in the 1930s, when federal relief projects proved conducive to the use of stone masonry for small bridges because their construction was relatively labor intensive. The Turner County bridges are discussed in a later section describing bridge-building activities in South Dakota during the 1930s.

Early Concrete Bridges

Concrete, which is a combination of cement, sand, and an aggregate, has been used since ancient times, but it was not until the 1880s that concrete construction began to be considered seriously in the United States. Because concrete is strong in compression and weak in tension, many early concrete bridges were monolithic affairs that did not create significant tensile stresses. The first monolithic concrete bridge in the United States was built in Prospect Park, Brooklyn, in 1871. Since the mid-19th century, developers of reinforced concrete had experimented with using steel bars or rods of various shapes and in various configurations to provide tensile strength in those areas of a structure expected to sustain tensile stress. Ernest L. Ransome built the first reinforced concrete bridge in the U.S. in Golden Gate Park, San Francisco, in 1889. He also patented a twisted reinforcing bar, a form noted in same of South Dakota's early reinforced concrete bridges.

One of the most influential reinforced-concrete bridge designers in the U.S. was a Viennese engineer named Joseph Melan. In 1894, he received a U.S. patent for his I -beam reinforcing system. The I-beams were bent to approximate the shape of the arch and arranged in series near the underside of the arch prior to pouring the concrete. Fritz von Emperger built the first bridge in the U.S. to use the Melan system in 1894 at Rock Rapids, Iowa. Several other bridges using the system soon followed in Iowa and Minnesota. Iowa's state Highway Commission, along with those in Illinois, Michigan, and Wisconsin, developed standardized plans for reinforced concrete bridges early in the 20th century. Apparently, the lessons of this pioneering work in reinforced concrete spilled into South Dakota, because the state's reinforced concrete bridges from before the 1920 creation of South Dakota's Bridge Department resemble the early designs from the other states.

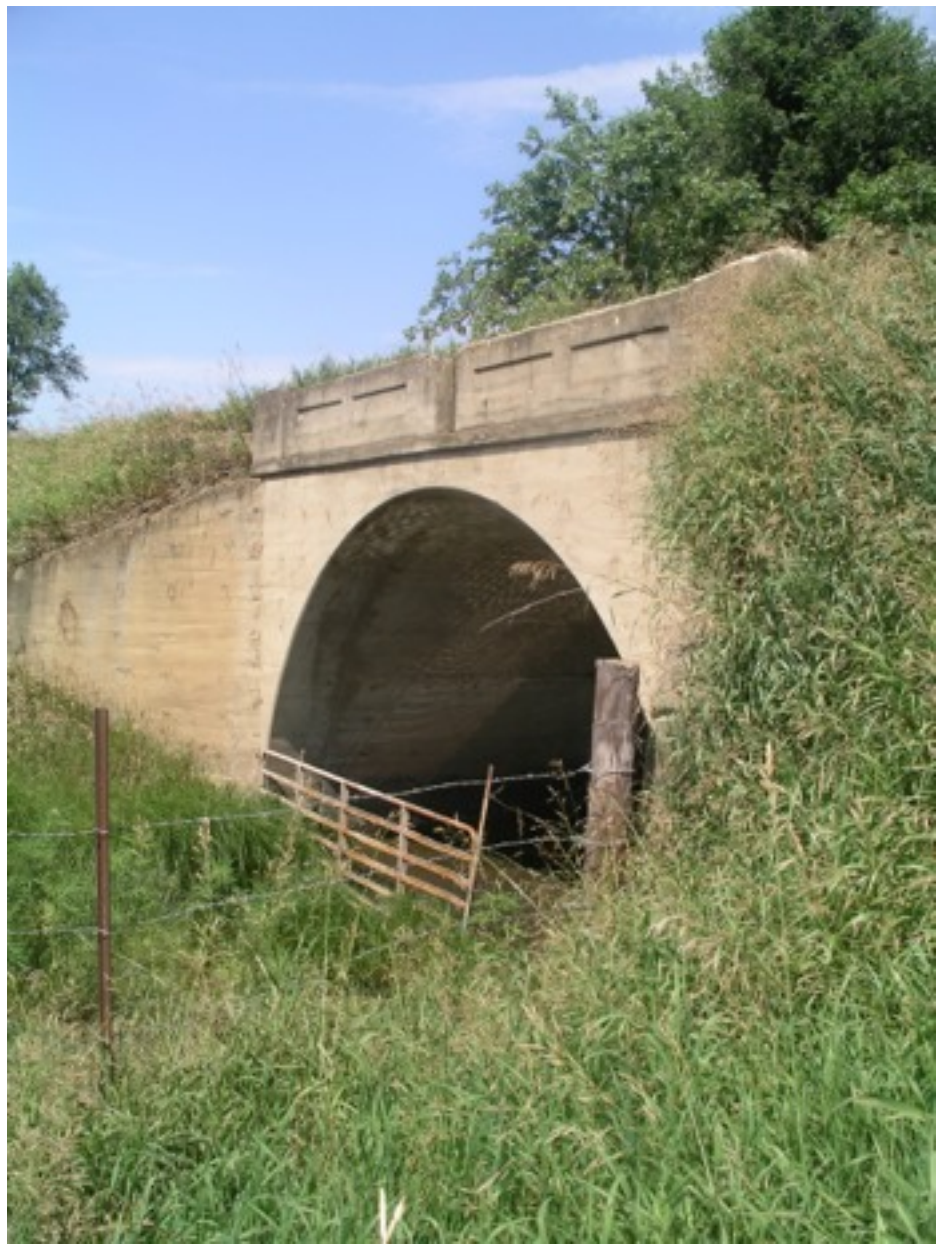
The earliest known concrete bridge construction in South Dakota occurred at Yankton in 1908. In November of the previous year, Mayor Rudy initiated a discussion at a City Council meeting of the feasibility of building a concrete bridge over Rhine Creek at Douglas Avenue. The matter was referred to the Committee on Bridges to be discussed with the W.L. Bruce, the city Engineer. Bruce replied:

> *A bridge of this kind once built would stand for ages without attention or repairs of any kind. While the cost of repairs and new floors over the present bridge will amount to enough to build the concrete structure in about 15 years. This style of bridge is one now generally constructed in city and county work throughout the Eastern states, where the great economy of such construction is better understood than here.*

Bruce estimated that the 36-foot wide x 56-foot long bridge would cost $2900. When bids were opened, George F. Ivory of Des Moines submitted the low bid at $5,800. The City Council rejected all bids and called for new bids. In July, the Council awarded a contract to build the bridge to John E. Quackenbush of Webster City, Iowa. Quackenbush, however, refused to stand behind Bruce's design, guaranteeing only his own workmanship on the project. Angered by this rebuff, Bruce refused to supervise construction of the bridge and resigned as city engineer. Quackenbush proceeded with the project, but when he struck the falsework in the fall of 1908, "cracking and crumbling" appeared in the spandrel walls, leading to charges and countercharges between the contractor and the former city engineer about the quality of design and workmanship. The bridge was demolished about 1960.

Despite the furor over the Douglas Street Bridge, the City Council was sufficiently pleased with the experiment to recommend, in the spring of 1909, that a concrete-arch bridge be built over Rhine Creek (now called Marne Creek) at Burleigh Street. That July, the Council selected plans and specifications prepared by N.M Stark and Company of Des Moines, awarding the firm a $3,500 construction contract. Although Quackenbush submitted a lower bid, the Council was evidently no longer interested in doing business with him. N.M. Stark completed the bridge in April 1910. Following the success of the Burleigh Street Bridge (which was replaced in 1989), the city of Yankton went on to build two similar concrete-arch bridges over Marne Creek in 1911 and 1912. They were designed by Hugh C. Liebe, the new city engineer who had previously worked for Bruce in his private practice, and were built by Ellerman and McLain, a local contracting firm.

Several other counties in the southeastern area of South Dakota also began building concrete arch bridges during the early 1910s. Among those surviving are the Pearl Creek Bridge in Kingsbury County, built by R.S. Warner in 1911; the Eighth Street Bridge in Sioux Falls, a three-span arch bridge built by N.M. Stark in 1912; and the two Riverside Township bridges



An early concrete arch bridge in the southeastern part of the state.

in Moody County built by Ward and Weighton in 1915. All of these bridges gave the appearance of being professionally designed.

In Rapid City, the Concrete Engineering Company began building concrete bridges during the late 1910s. Based on their relatively good condition following over seventy years of exposure to western South Dakota's climate, it appears that the bridges of the Concrete Engineering Company were well designed structurally. On the other hand, their appearance is more vernacular in character than comparable bridges in the eastern part of the state, primarily because of their railings, which contrast with the neoclassical treatments given railings of eastern bridges. The Minnesola Bridge near Belle Fourche in Butte County is a documented example of a Concrete Engineering Company structure. Another likely product of the firm is the Rapid Creek Bridge near Farmingdale in Pennington County. Both feature unique guardrails displaying bold, castellated shapes.

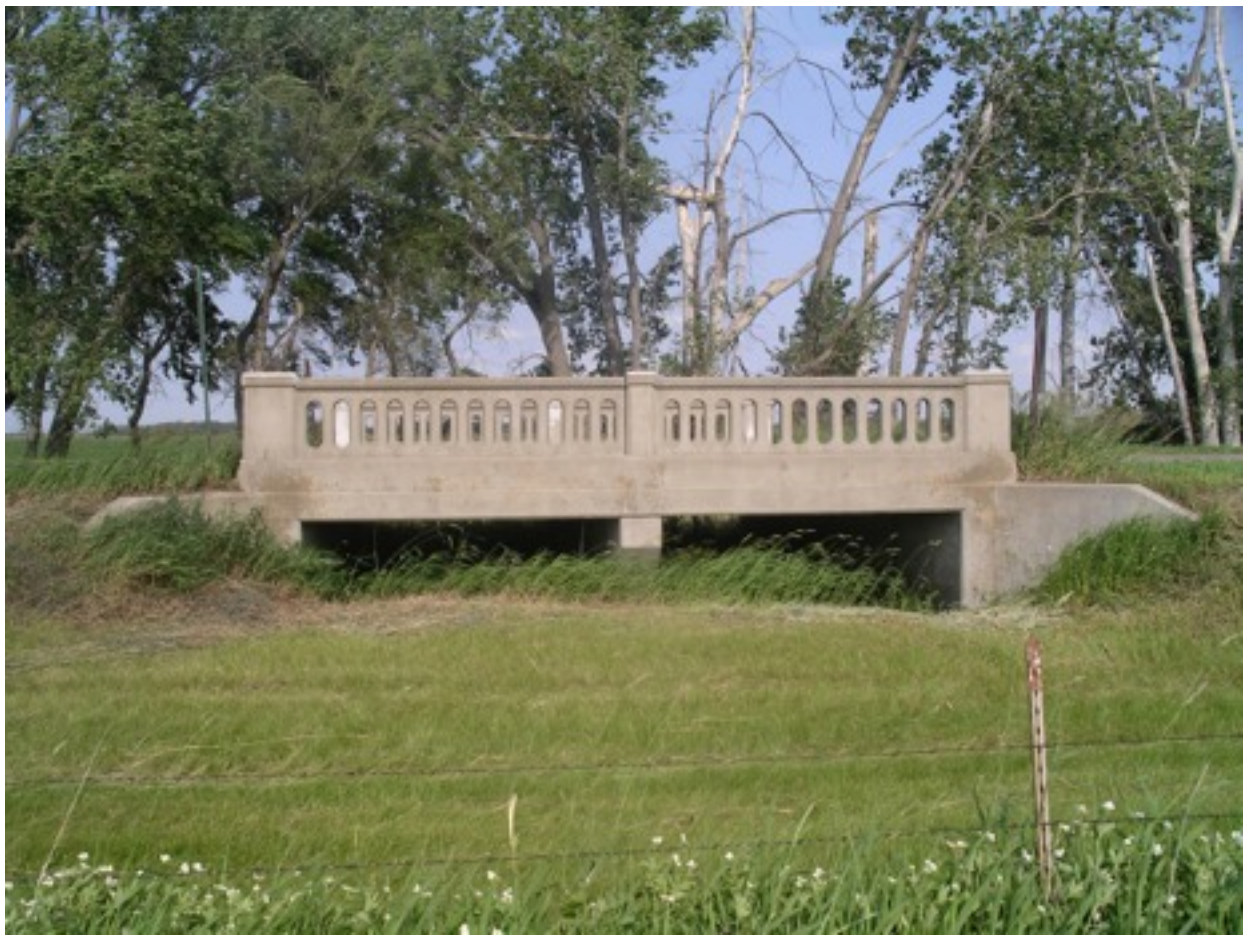
Although the first concrete bridges in South Dakota appear to have been arched structures, concrete slabs and concrete girders were soon to follow. One form of concrete slab structure came to be known as the boxed culvert. It featured concrete side walls supporting a concrete slab, which in turn supported the earthfill upon which the roadbed was built. A related kind of bridge was used by the Chicago, Milwaukee, St. Paul & Pacific Railroad to create grade separations where county roads intersected its tracks. These structures, typically carrying railroad tracks over vehicular roads, survive as among the oldest concrete bridges in South Dakota.

Concrete slab bridges are distinguished from concrete box culverts by two factors: generally, the slab also serves as the deck for a bridge, while the culvert supports earthfill for a roadway; for multiple spans, a bridge has piers consisting of two or more concrete bents (vertical posts), while a culvert has solid concrete piers separating the spans into distinct compartments. Also, it is general practice to categorize structures with spans less than ten feet as culverts and structures with greater spans as bridges (federal standards set 20 feet as the dividing line between culverts and bridges). A number of these bridges survive in South Dakota today, some dating from as early as the 1910s.

Early concrete-bridge contractors also had access to plans for concrete-girder bridges, consisting of concrete girders spanning between abutments or piers and supporting a concrete deck. Frequently used for small-span structures beginning in the 1910s, many survive in South Dakota today. The earliest of these bridges have guardrails consisting of solid concrete parapets with recessed panels, a typical feature of early state-designed concrete bridges.

The 1910s also saw the use of concrete to fashion much longer arch spans, but these used significantly more steel that the simple barrel arch, slab, or girder bridges. J.B. Marsh of Des Moines developed and patented the design, known as the Rainbow Arch or Marsh Arch. Marsh graduated from Iowa State College of Agriculture and Mechanical Arts in Ames with a degree in engineering in 1882. The next year, he began working in the Des Moines office of the King Bridge Company of Cleveland, Ohio. By 1889, he was general western agent for the King Bridge Company and in charge of its Des Moines office. Marsh formed his own Marsh Bridge Company in Des Moines in 1896, began investigating the use of steel and concrete together, and became a leader in the technological studies that resulted in the general acceptance of reinforced concrete for bridge construction. In 1909, he changed the name of his company to the Marsh Engineering Company. The company apparently became active in South Dakota when it received the contract from Clay County for bridges in 1911. No bridges built by Marsh are known to survive in South Dakota, but it was his design for the Rainbow Arch that had the more important impact on the state's surviving collection of concrete bridges.

In 1911, Marsh made a patent application for the Rainbow Arch design. His design was a two-ribbed concrete through arch. The cores of the arches were a steel arch consisting of lattice work similar to the chords of a truss bridge. The first step in construction was to assemble and erect the steel much like a steel truss. Once the steel ribs were set on the abutments or piers and the vertical steel hangers, the steel floor beans, and the steel



Most of the state's early concrete bridges featured a concrete balustrade with oval cutouts, rather than the pipe railings often used in later structures.

reinforcing for the deck were put in place, concrete was cast around them in a specific order. The arch ribs were encased in concrete first, followed by the floor beans and floor slab, the bridge railing, and finally the vertical hangers. Two Rainbow Arches survive in South Dakota, the oldest of which is at Miller. The Iowa Bridge Company built the 40-foot span for Hand County over Ree Creek in 1914. The other, dating from 1917, is the Capitol Street Bridge over Marne creek in Yankton. It was built by the local Ellerman and McLain Company.

Besides the Marsh Engineering Co., the other leading out-of-state concrete bridge company was the firm of Ward & Weighton of Sioux City, Iowa. Ward & Weighton's earliest South Dakota activity was in 1911 when they received the annual contract for concrete bridges in Moody County. Ward & Weighton also had annual contracts in Davison and Clay Counties. Two Ward & Weighton bridges survive in Moody County. Built in 1915, they are both 30-foot concrete-arch structures.

The out-of-state steel bridge companies never seemed to monopolize the concrete bridge building market as they had with steel bridges earlier, although many of those bridge companies that built primarily steel bridges bid and built sane concrete bridges as well. The introduction of the new technology of concrete construction permitted several South Dakota contractors to enter the bridge building business. Local concrete companies competed successfully in several areas. Such companies included: Carl Schultz of DeSmet, R.S. Warner, and the Arlington cement Co. were all awarded contracts in Kingsbury County in 1912. W.A. Barnhart of Salem was particularly successful in McCook County, apparently building all concrete bridges there from 1913 through 1917. W.F. Woolworth of Clear Lake received a contract in 1914 for 13 "cement" arch bridges in Deuel County. And in Codington County, the commissioners accepted designs for concrete bridges submitted by the Watertown Cement Products Company as the standard plans and specifications on which all contractors had to bid, although in subsequent bidding, the Security Bridge Company, known more for its truss bridges, was the successful bidder. In 1917, the South Shore Cement Works was the successful bidder for building same Codington County concrete bridges, including a reinforced concrete slab bridge south of Rau. None of these contractors are known to have played major roles in bridge construction on a statewide basis, but they do demonstrate a characteristic of reinforced concrete: it was a building technology that was more accessible to local contractors than steel truss construction had been.

Patterns of Bridge-Builders' Business

Once local governments began paying contractors to build bridges in South Dakota, counties advertised for bids on individual bridges or small groups of bridges and awarded contracts, usually, but not always to the lowest bidder. Often, when counties received bids for groups of bridges, they awarded contracts to a number of different companies at the same letting. Initially, there was no apparent pattern concerning which company received bids in a particular county. By the late-1890s, however, individual bridge companies began receiving virtually all contracts in same counties. As early as 1893, Minnehaha County referred to S.M. Hewett & Co. as "the county bridge contractors" because the company had a contract to build all bridges in the county during the ensuing year.

Beginning in 1903, the practice of awarding "annual contracts" became commonplace. Typically, county government would advertise for bids for several different bridge types on a unit-cost basis – so much per lineal foot, another amount for substructures, and yet another for approaches – all based on plans and specifications supplied by a bridge company, most often the company holding the previous year's contract. Of the 22 counties which apparently awarded annual contracts in 1905, the Iowa Bridge Co. held annual contracts in exactly one-half, most located along the Milwaukee Road's line from Yankton to Aberdeen. Other companies with annual contracts were the Standard Bridge Company of Omaha with three; John W. Towle of Omaha and William S. Hewett of Minneapolis with two; and the Canton Bridge Company, the Joliet Bridge & Iron Company, A. Y. Bayne & Company, and the George E. King Bridge Company each with one. In most cases, companies were receiving annual contracts year after year in "their" respective counties.

In 1912, the year after the South Dakota legislature passed a law requiring the counties to award annual contracts, thirty-two counties researched during this project awarded annual contracts. They were divided among various companies as follows: the Iowa Bridge Company of Des Moines had annual contracts in seven counties, the Standard Bridge Company of Omaha had six, the Federal Bridge Company of Des Moines had five (all of which formerly had annual contracts with the Iowa Bridge Company), the security Bridge Company of Minneapolis and the Western Bridge and Construction Company of Omaha each had four, the Canton Bridge Company of Canton had two, and C.E. Gilbert of Aberdeen, the Pioneer Bridge Company of Mitchell, Omaha Structural Steel, and Mike Gales of Plankinton each had one. Although some of the series of annual contracts lasted for only a few years, others continued almost two decades. For example, the Iowa Bridge Co. held the annual contracts in Spink, Beadle,

and Brookings Counties from 1903 until at least 1919. The Standard Bridge Co. dominated bridge construction in Gregory County over the same span of years.

With the gradual acceptance of reinforced concrete for bridge construction in the 1910s, annual contracts were often awarded separately for steel trusses and concrete work. The firms of Ward and Weighton of Hawarden, Iowa, and the Marsh Engineering Company of Des Moines were the primary out-of-state contractors for concrete bridges. Unlike the domination of the steel bridge market by out-of-state firms, however, many South Dakota companies constructed concrete bridges, including the Concrete Engineering Company of Rapid City, the South Shore Cement Works of South Shore, the W.A. Barnhart Construction Co. of Salem, and W.F. Woolworth of Clearlake.

What at first might appear as the development of a mutually beneficial relationship between the county commissioners and the bridge builders is more likely due to "pooling," which was a common practice throughout the United States in the late nineteenth and the early 20th centuries. Under pooling arrangements, the bridge companies agreed to divide states among themselves, assigning particular counties to specific bridge companies. Whenever a county advertised a bridge construction project, agents for each of the companies would meet near the site and discuss the cost of the project. If they could agree, they would permit the company in whose territory the bridge was to be built to submit the low bid, allowing for a comfortable profit. The others would submit higher bids. At the conclusion of the project, the successful bidder would disperse a portion of the profit to the other companies in the pool. Companies bidding early in South Dakota such as the King Iron Bridge and Manufacturing Company, the Wrought Iron Bridge Company, S.M Hewett, R.D. Wheaton & Co., and the Gillette-Herzog Manufacturing Co. are all known to have participated in the practice in other states.

Although there is no documented evidence that bridge builders in South Dakota participated in pooling arrangements, in a 1980 oral history, Kenneth R. Scurr, former South Dakota Bridge Engineer, described bridge building practices prior to the establishment of the state Highway Commission:

> *The county commissioners of each county were solely responsible for their own roads, bridges and culverts. The plans for these structures were furnished by the bridge companies who dealt directly with the counties. Several bridge companies had established themselves with the county commissions and in reality honored each other's territory and when a county required a bridge and held a let-*

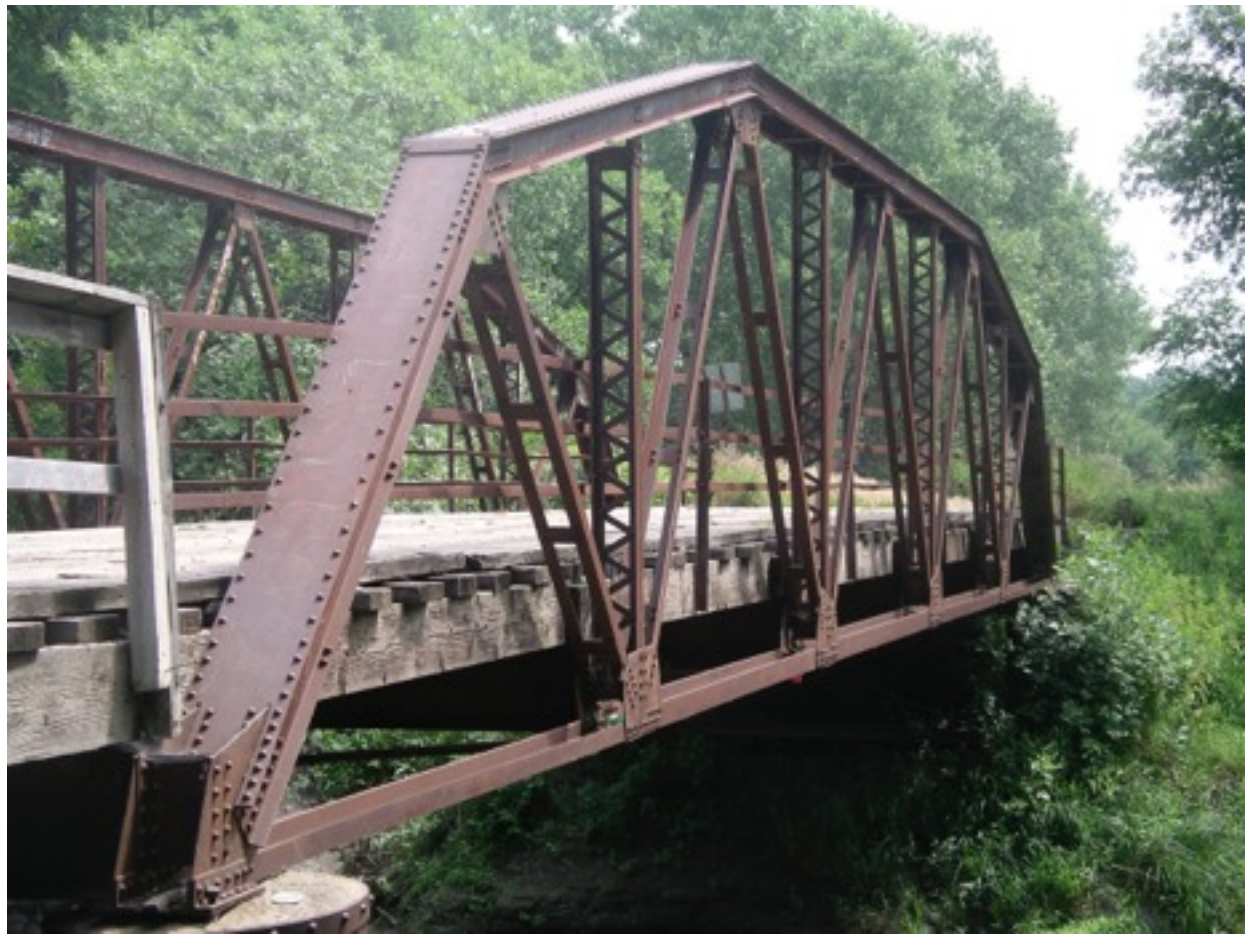
ting each seemed to honor the territorial rights of the others and there was rarely any real bidding.

Further evidence of pooling arrangements came to light during political speeches in 1922 whim found Democrat Louis N. Crill criticizing the administration of Governor William H. McMaster. Crill advocated that the relatively new State Highway Commission be abolished as unnecessary and wasteful of taxpayers' money. McMaster, who had been Lieutenant Governor under the previous Governor, Peter Norbeck, defended the state Highway Commission, which had been instituted under Norbeck's direction. McMaster countered Crill's accusations by saying that prior to the inception of the Bridge Department of the State Highway Commission, South Dakota's counties had been in the grip of a bridge "trust" which colluded to keep the costs of bridges uncompetitively high.

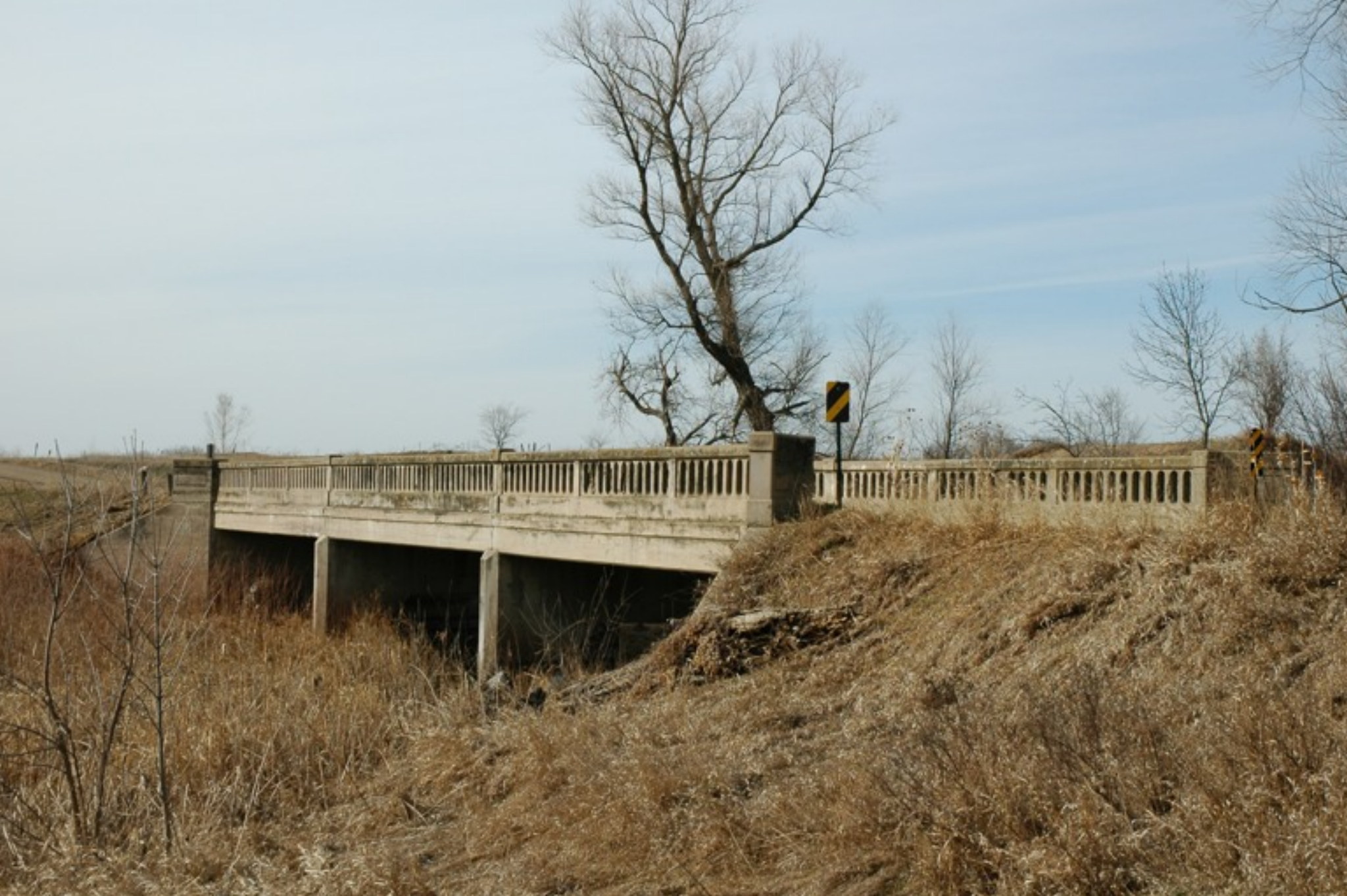
Whatever the relationship that had developed among the bridge builders, the commissioners records usually showed little dissatisfaction among the county commissioners. In fact, counties sometimes renewed annual contracts with “their” bridge builders without calling for new bids. For example, in December 1903, the Iowa Bridge Company won the annual contract in Beadle County bidding against five other contractors. In January 1905, the Beadle County Commissioners voted to renew the company's contract without requesting new bids. The county advertised for bids the following several years, but then in April 1909, again renewed the Iowa Bridge Company's contract without requiring bids. Likewise, the Gregory County Commissioners extended the Standard Bridge Company's contract in July 1904 without requesting bids. Occasionally county commissioners would reject all bids and re-advertise. Unfortunately, minutes of meetings are not detailed enough to suggest why the bids were rejected, and often when new bids were opened, the usual low bidder still got the contract.

As the numbers of bridges constructed grew steadily in the 1910s, some of the counties tried to resist the costs charged by the bridge contractors. Several counties, Codington, Jackson, and Hand among them attempted to use county forces to undertake required work. Nevertheless, the counties still had to purchase fabricated bridge components from out-of-state. When Hand County began building its own bridges in 1915, it purchased steel from the Minneapolis Steel and Machinery Company. Minneapolis Steel and Machinery is representative of the large early-20th-century fabricators which served the region with structural steel. It was formed by Lewis and George Gillette after the American Bridge Company took over their Minneapolis-based Gillette-Herzog Manufacturing Company in 1900. In 1908, the company had 1200 employees, 60 times more than the total employment in all of South Dakota's foundries and machine shops. The Minneapolis Steel and Machinery Co. also provided standard sets of bridge

specifications for local governments. The specifications were developed especially to address the greater stresses being placed on rural bridges by heavy steam traction engines in agricultural areas. Hand County may have adopted these standard specifications for use by its county crews.



This riveted "Camelback" truss design is representative of truss bridges built in South Dakota after the 1910s.



5

THE STATE BRIDGE ERA

The 1889 Constitution of South Dakota contained a provision that was to thwart the state's early involvement in responding to the public's demand for improved public roads and bridges. The single sentence, “[n]or shall the state engage in any work of internal improvement,” delegated the responsibility for building and maintaining roads and bridges to the counties and townships. A constitutional amendment was required to empower the legislature to expend public funds on roads and bridges. Without the ability to back its sentiments with appropriations of money, the legislature was ineffectual in promoting a coordinated statewide road system. As a consequence, the different counties and townships addressed their own perceived needs, with coordination limited to sharing costs for an occasional county-line road or bridge.

Governor Charles Herreid became the first state official to call for improved roads. In his 1903 message to the state legislature, he pleaded unsuccessfully for legislation to reform what he considered a foolish and wasteful system. In 1907, the South Dakota legislature debated a bill, that would have required all roads to be constructed under the supervision of the county commissioners, but it failed to pass. A provision requiring that road taxes be paid in cash rather than in labor was successful, however, ending the practice of taxpayers offering labor on roads and bridges in lieu of cash. The 1911 Legislature passed the "Issenhuth Bill," probably the most important piece of legislation affecting roads and bridges prior to the creation of the South Dakota state Highway Commission. The bill specified the manner in which County Commissioners were to seek bids for bridges, requiring the commissioners to award annual contracts on a per lineal foot basis. It also required that the counties hire “practical engineers” to oversee all roadwork.

The creation in 1913 of the South Dakota State Highway Commission (SHC) by the state legislature was the first mowe towards state participation in road improvement. The statute creating the SHC granted little authority and included no appropriation for salaries and expenses. The law provided that the SHC “whenever practicable ... shall investigate and determine the location of road material, ascertain the most approved methods of construction and improvement of roads, and investigate laws in relation to roads in other states” and “shall prepare and adopt such rules and regulations for construction and improvement of roads that will bring the most practical results.” The counties were given the power to designate state roads and “make all necessary surveys, estimates and specifications for work done on state roads” subject to approval by the SHC. The only mention of bridges was in section 9: “Road or highway shall be construed to include all bridges.”

The first report of the SHC to the governor bemoaned the lack of an appropriation to support the SHC's activities. The second report of the SHC called for funding and requested the authority to “employ a practical engineer.” The SHC also noted its desire to adopt a set of standard plans and specifications, with the intent to build “only such bridges and culverts as will successfully hold up and survive the peculiar destructive elements that are and will be encountered at the particular location of such bridges or culverts.” These recommendations were clearly in response to the county commissioners determining the location and design of bridges without the advice or assistance of bridge engineers.

Previous page: a 1930s-era reinforced concrete-stringer bridge in Brown County, a standard design of the era.

Charles Mix County apparently led a protest in 1915 over the Legislature's plan to transfer some responsibility for road and bridge construction

from the local level to the SHC. Joining the protest, the Codington County commissioners told their legislative representatives that they did not feel that the SHC could "handle the work effectually and as economically [as the county, since it would] build its own bridges."

Still hampered by the constitutional restriction against providing direct funding for road construction, the 1915 legislature did not grant complete control for roads and bridges to the SHC. Nonetheless, it began tightening the state's regulatory control over bridge design and construction and the maintenance of roads. The counties were required to construct "all bridges, abutments and approaches or repairs ... in accordance with plans and specifications prepared by the state Engineer," to receive the engineer's approval of all contracts over $2,000, and to have the state Engineer, or an engineer approved by him, supervise construction of all bridges built under contract greater than $3,000. Also significant was a law permitting the counties to levy two mills above the levy of the townships for county roads and allowing the levy to be raised to five mills with voter approval.

The 1915 report of the SHC noted that only four counties did not have a road levy, that only five counties did not have a bridge levy, and "that the bridge levy still exceeds the county road levy by $88,883." The report remarked on the moves in the U.S. Congress to provide federal aid for road construction and recommended that the state amend its constitution so it would be prepared to participate in the program.

The prospect of federal financial assistance coincided with the 1916 election of progressive Republican, Peter Norbeck, as governor. A successful Redfield businessman, Norbeck had a long interest in, and enthusiasm for, improved roads. He drove the first automobile into the Black Hills in April 1905. At one point on that trip, three cowboys using lariats pulled the one-cylinder Cadillac across the Cheyenne River. In his first message to the legislature, he urged an extensive program of road construction.

With the enactment of the Federal Aid Road Act of 1916, the United States Congress authorized the Department of Agriculture to provide federal aid to the states of up to fifty percent of the cost of approved road construction projects. It also stipulated that applications for proposed projects had to be submitted through the state highway departments. This latter provision was purposefully directed to establish centralized authority for road construction in the states and end the haphazard construction programs of the counties. Provisions for adequate maintenance of roads constructed with federal aid were also included.

The South Dakota Legislature met in special session during 1916 to prepare a resolution repealing the constitutional provision prohibiting the state from engaging in the construction of public roads. The resolution was approved by the voters in November. The 1917 South Dakota legislature repealed the 1913 law providing for the SHC, replacing it with the South Dakota State Highway Department. It also agreed to abide by the provisions of the Federal Aid Road Act and pledged the faith of the state to provide funds. The three-member State Highway Department consisted of the governor, the state engineer, and an experienced road builder appointed by the governor. Provision 5 stipulated:

> *It shall be the duty of the State Highway Department to supervise, control and direct the building of public roads and bridges, for which state or Federal Aid is granted. The department also has the power to prepare and adopt such rules and regulations as would bring the most practical results to various parts of the state.*

The law also gave the State Highway Department the authority to select and designate State Highways. Although the State Highway Department laid out seven Federal Aid projects for 1917-1918, no projects were completed.

The 1919 South Dakota legislature reorganized the department, returning the earlier name, state Highway Commission. The reorganized agency was administered by two, full-time, salaried commissioners appointed by the governor, who also served as ex-officio chairman. The law provided funding for salaries and expenses. The Commission was given "general supervision of the administration of all road and bridge laws, and over the construction and maintenance of all roads, bridges and culverts" funded with federal or state aid. The legislature directed in the SHC to designate a state Trunk Highway System connecting every county seat and every city with a population of 750 or more. The legislature also directed county commissioners to select and designate county road systems and hire county highway superintendents who were given charge of all road construction and maintenance in their respective jurisdictions, including the maintenance of the Trunk Highway System. The administrative relationship the legislature established between the South Dakota State Highway Commission and the counties remained in place through the next two decades.

John Edward Kirkham

The infancy of the South Dakota State Highway Commission in bridge design was to prove an irresistible attraction to John Edward Kirkham, who was at that time serving as consulting engineer to the Highway Commission of Iowa. Kirkham spent his 1919 summer vacation with the South Dakota State Highway Commission "just to help out." He was ready for a change, having grown displeased with the Iowa commissioners for their belief that he had reached the pinnacle of his bridge designing capabilities, because his "designs were used by other states from Maine to California." Kirkham found the South Dakota SHC without its own plans, relying instead on those copied from bridge companies and some of his Iowa bridges designs.

John Edward Kirkham was born in 1870 at Covington, Indiana. His grandfather, C.V. Garlinghouse, was an inventor and his father a captain in the U.S. Army. Kirkham spent his childhood attending army post schools before graduating from the University of Missouri with a degree in civil engineering. Early in his career, he worked for the noted Kansas City bridge engineer, J.A.L. Waddell, and held positions with the Carnegie Steel Co., the Missouri Pacific Railroad Co., and the Pennsylvania Steel Co. He was also an instructor in civil engineering at Pennsylvania State College and a design engineer with the American Bridge Company before taking a position on the engineering faculty at Iowa State College. In correspondence in

John Edward Kirkham.

1925, Kirkham related that in his early experience with a small bridge company he “was tutored in the ways that highway bridge construction was handled throughout the states.” He found the methods so “distasteful” that be began designing bridges. In 1907, he responded to a request of the Alumni Association of Iowa State College “to try to improve highway bridge construction. I realized before starting the work that I would be strenuously opposed by those who were pleased (particularly in a financial sense) with the present arrangement and I was.” Nevertheless, after fights in the courts and the legislature, he succeeded in “getting good designs adopted and constructed at a fair cost to the taxpayers of Iowa.”

During the summer of 1919, Governor Norbeck gave Kirkham a personal tour of South Dakota. During the tour, Kirkham explained to the Governor how he “could save hundreds of thousands of dollars to the taxpayers by building bridges in conformity with economical and geological conditions as found through the state.” The governor in turn offered Kirkham the position of bridge engineer, which he '”would be permitted to carry out without interference from anyone.” Although Kirkham questioned the adequacy of the salary, he also found the idea of creating his own organization appealing, since there were no “so-called experts [on staff who] would only be a hindrance.” He accepted the position in October 1919.

Kirkham immediately attacked South Dakota's bridge needs with vigor and determination, working “night and day and holidays getting out designs suitable for the conditions found throughout the state.” Two of Kirkham's former students from Iowa State College were working for the South Dakota SHC and he had them transferred to the Bridge Department. In February 1920, he hired three additional former students, and then three more in June. Kenneth R. Scurr, one of those hired that year stated in an oral history late in his life that “[t]his predominantly Iowa state group was the best testimonial of Mr. Kirkham's confidence in the efficacy of his own teaching.” Kirkham started without apparent pre-conceptions, throwing out his Iowa bridge designs and “ignoring the plans previously used by the [South Dakota State] Highway Commission.”

Kirkham found that he not only had a bridge department to organize, but he also had to overcome the “prejudice” of the county commissioners, whom he found “not friendly to the new highway law” or those representing it. Kirkham's belief that the counties should build as many permanent bridges as they could afford each year while putting up cheap temporary bridges for the remainder was met with opposition from county officials, who said they could not afford such permanent structures. Kirkham's contention that “the only way that the bridge taxes could be reduced was by building economically permanent structures” was documented in

1925 when he showed that the cost of highway bridge construction in South Dakota had dropped from a high in 1920-21 of $2,690,000 to a cost in 1923-24 of $1,028,751. He predicted a dramatic drop in the bridge mill levy as the counties completed all of their permanent structures.

In 1921, Kirkham's Bridge Department provided plans and specifications for 538 bridges, 1462 box culverts, and numerous repair projects. Some were based on standard plans the Department developed for steel bridges, including pony trusses, and for concrete bridges and abutments. The Bridge Department claimed to have saved the counties about $700,000 that year, fulfilling Kirkham's pledge to Governor Norbeck that by providing special designs he could save the taxpayers “hundreds of thousands of dollars.” The major bridges designed in 1921 were a 1050-foot steel bridge over the Cheyenne River in Ziebach county, a 640-foot wooden bridge over the Cheyenne River near Hot Springs, a 400-foot steel bridge over the White River between Tripp and Lyman Counties, and a 300-foot steel bridge over the Belle Fourche River, north of Wasta in Meade County, none of which survive.

Kirkham's ability as an innovative designer did not succumb to the tremendous workload of providing plans for state and county bridges. Recognizing that the inferior quality and appearance of the concrete work was largely due to a lack of knowledge and direction on the part of the contractors, Kirkham developed a design for box culverts which was more durable and required less maintenance than the types that had been in use. “[Bly scientific designing,” the amount of concrete required for concrete box culverts had been reduced at a savings of $500,000 to the counties. The single, double, triple, and quadruple culverts included a two and one-half foot handrail for safety and aesthetics. Several early SHC-designed concrete box culverts survive. A good example is the structure over Ferney Ravine just north of Ferney. Consisting of three 8¬foot-wide box culverts, it was built by Pickus Construction in 1923 using standard SHC plans.

Kirkham also developed the design for an “absolutely ... permanent” concrete viaduct for low flat crossings at locations that were dry except for a few weeks in the spring. The continuous-slab viaduct was designed for sites that would experience slow current and little ice. Named by Kirkham the “Beadle County Special,” it consisted of 10-foot spans resting on light concrete abutments and concrete bents. The design featured gaspipe railings supported by concrete posts. The cost of the continuous-slab bridges was estimated to be one-half of the typical solutions used up until that time. Kirkham also claimed that the only maintenance required would be periodic painting of the steel pipe, and “if this be neglected, the pipe will last for many years, and if they should rust out or be broken, they are loose at the ends so that they can be easily replaced.” Several of these bridges

survive in South Dakota. The “Beadle County Special” with the best integrity in Beadle County is a 45-foot long structure (four spans) over an unnamed creek about 11 miles north of Wessington.

In cases where longer spans were required, Kirkham recommended I-beam spans. Single-span I-beam bridges were virtually identical to those being built by contractors for counties prior to the formation of the Bridge Department. Multiple-span bridges, on the other hand, had the outer I-beams on each side entirely cast in concrete. Kirkham's idea was that only the outer I-beams of a bridge were subjected to the elements. Encasing them in concrete and giving;] the other I-beams two coats of paint at the time of construction would yield a bridge requiring “practically no maintenance.” Coupled with the gaspipe railings and concrete posts, the appearance of the outer beams made these bridges look more like reinforced concrete structures and, in fact, they were called “reinforced concrete viaducts.” The oldest surviving reinforced concrete viaduct (I-beam structure with outer beams cast in concrete) is the 1921 bridge on the north side of Faulkton over the South Fork of Snake creek consisting of three 30-foot spans. Although extant examples of the reinforced-concrete slab bridges and the reinforced concrete-viaducts have gaspipe railings and standardized plans showed the gaspipe railings as typical, some early bridges designed by the Bridge Department had ballustraded concrete guardrails, a feature that became typical on SHC bridges in the 1930s.

Kirkham also designed the “tar wood floor” to replace the wood floors on light steel bridges that could not take the added weight of a concrete decks. The floor consisted “of 2 x 4-in. planks dipped in boiling coal

Builder’s photo of an early 1920s bridge in central South Dakota, constructed using Kirkham’s standard design.

tar, placed on edge across the roadway and nailed together. This solid 4-in. floor is covered with a layer of either tar and sand or tarvia and sand about 1/2 in. thick." At a cost of twice the standard floor, it was estimated it would last for twenty years if the wearing surface were replaced every five or six years. Kirkham also claimed that the floor distributed the load more uniformly over the structure. The February 1923 Engineering News-Record carried an article on "tar wood floor" in which it was compared to a similar flooring used on sane of Chicago's viaducts. A few bridge decks of this type survive in South Dakota, and whether they date from Kirkham's era or not, continue to attest to Kirkham's predilection to develop bridge-building techniques that could save the counties money through reduced maintenance costs.

Another innovative program Kirkham devised was the construction of state and county bridges by crews that were directly trained and supervised by the Bridge Department. The "force-account system," as it was called, was ostensibly established to build bridges in remote locations that did not attract bidders. A 1920 letter from Kirkham to the Davison County commissioners, however, indicates that the force-account system was as likely developed to break the control of the bridge builders over the counties. In that letter Kirkham stated his belief that the bids for an advertised bridge were "entirely too high":

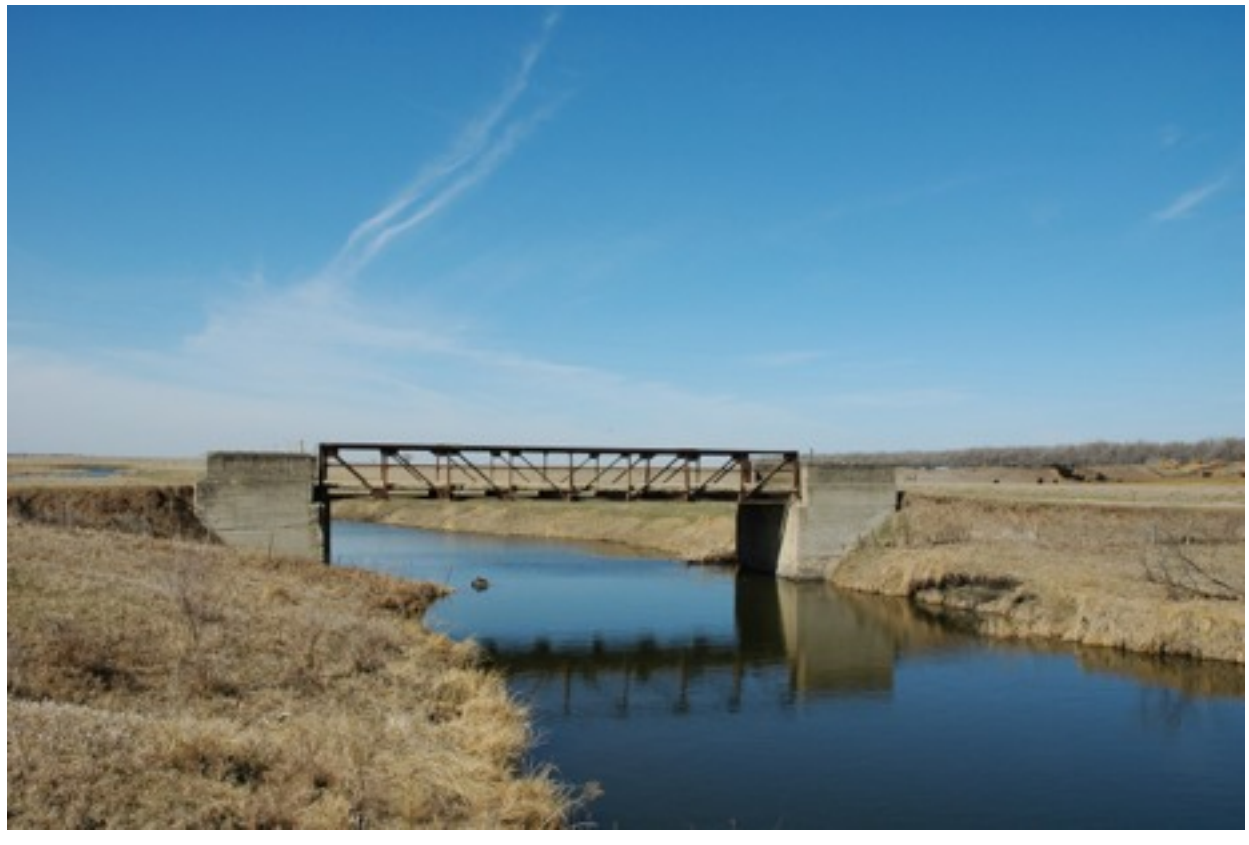
> *If the constructors are not willing to build this bridge at a fair price I see no way except for me in cooperation with the County to put a crew in and construct this bridge on "force account." We can do the work just as quickly as the contractor and at much less cost. The contractors east of the Missouri River seem to think that I do not intend to defend myself, but they will soon find out that I, in cooperation with the counties, can build up just as many crews as the counties need, and if they force the issue we will do so.*

Kirkham actively opposed the bridge builders and the excessive rates he thought they were imposing. Minutes of commissioners meetings in several counties record Kirkham being present to discuss new procedures in general or to address specific bids. In an appearance before the Roberts County commissioners on June 1, 1920, Kirkham recommended that the commissioners cancel recent contracts with three bridge-building companies because he believed the prices were too high. The commissioners responded accordingly, but found themselves without any bidders when they readvertised the projects two months later. The commissioners delayed construction until 1921 when they received acceptable bids. In his 1922 response to criticism by Louis Crill, governor McMaster cited several examples where state forces built bridges at considerable savings over the contractors' bids. In one instance in Jackson where Kirkham's department

thought the bids for two bridges over the White River were too high, Kirkham had Jackson County hire the low bidder to build the bridge at Presho while state forces built the nearly identical bridge at Kadoka. Cost of the bridge built on “force account” was $12,000 less than that built by the contractor at Presho.

By 1921, the SHC field force included one full-time construction crew, and one part-time construction crew. The first bridge built by force account was the 300-foot two-span Parker through truss at Kadoka over the White River. Other bridges constructed by force account included a 280-foot bridge over the Belle Fourche River north of Underwood, a 65-foot bridge over Sulphur Creek in Meade County, and the Camp Crook bridge over the Little Missouri River. None are known to survive.

Part of the savings Kirkham accrued by using SHC construction crews was from working the men hard, as he made clear in correspondence with Butte County in 1921. Kirkham offered to move his crew from Camp Crook to Butte County to construct the White Wood Creek Bridge. The County would be responsible for paying the crew while they worked on the bridge. The state Aid Engineer followed Kirkham's letter with one of his own urging the Auditor to “indicate to the commissioners that this arrangement is the best possible one which they could have in order to get cheap bridges, as the work is done by this crew at cost and the county is relieved from any supervision.” Worried about uncertain weather conditions, the commissioners questioned whether they would have to pay the crew “straight time” or just for the time they worked. Kirkham explained that “I never pay the men except for the actual hours of work. You can readily see

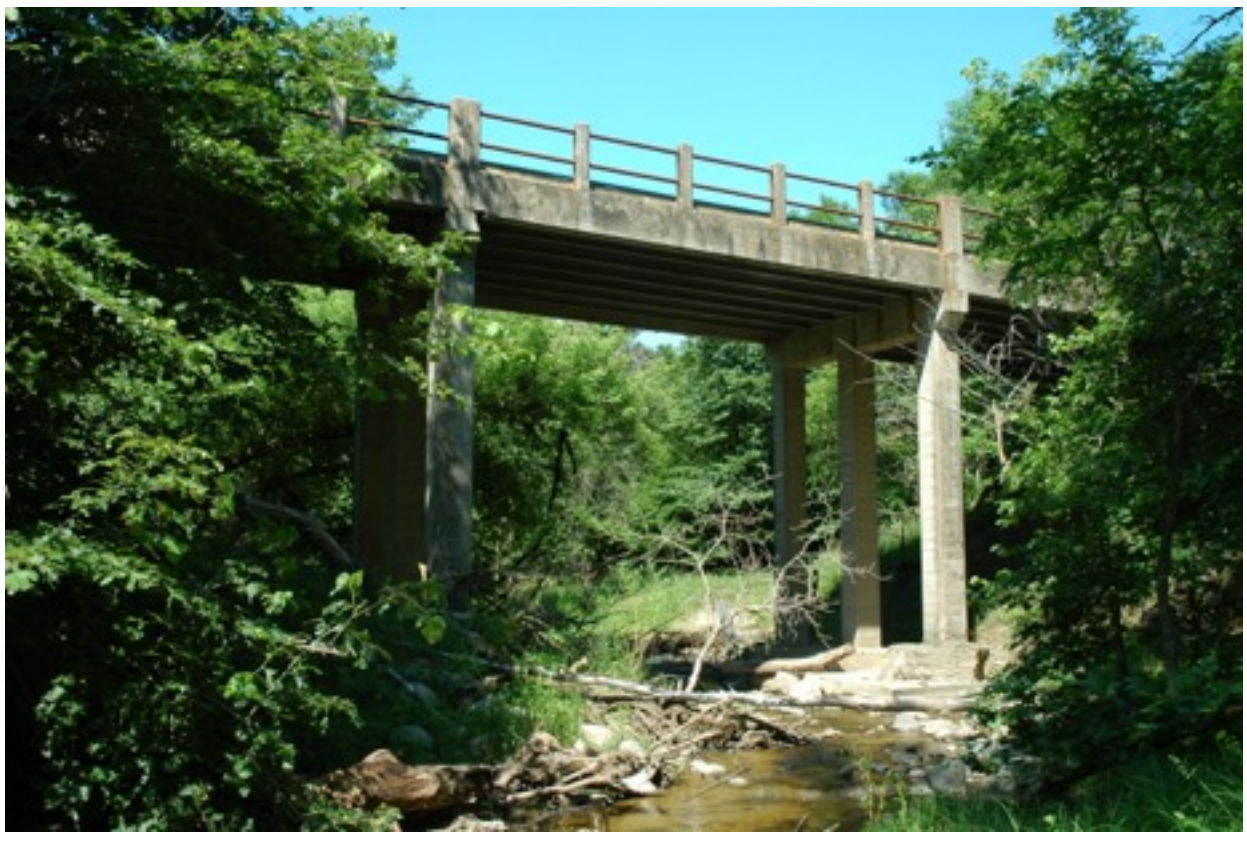


Numerous examples of Kirkham’s “bedstead” truss design still survive in South Dakota, particularly in the north-central part of the state.

that straight time would be entirely out of the question with me as there would be no incentive to work when the weather was a little disagreeable. My only reason for offering to put my men on the White Wood Creek bridge is to help out your county, as it surely needs help on bridge construction."

The 1922 Annual Report of the Bridge Department claimed that Kirkham's new bridge designs for South Dakota were not being "built in any other state of the Union" and that they had saved the state and counties close to $1 million out of a total bridge construction cost of $1,771,000 that year. The bridge department staff of five (Kirkham, two designers, one draftsman, and one tracer) had furnished designs for 495 bridges, specially designing 411 of those. The special designs did not usually mean new types of designs but rather adapting standard designs to site-specific needs. The unrelenting demands of time on the Bridge Department were beginning to take their toll on Kirkham's ability to continue research into bridge design and he recommended adding at least three additional staff members.

Kirkham's research led to designs for bridges which could be at variance with standard practice elsewhere. For example, the Bureau of Public Roads, U.S. Department of Agriculture, which was developing nationwide specifications for federal-aid bridges, took issue with Kirkham's bedstead-type pony truss with single-web upper chords. The upper chords of Kirkham's trusses consist of paired angle sections with a channel section top cover plate. The adjoining angle sections comprise at T-section, the stem of which forms the single web. The Bureau of Public Roads preferred upper chords with box sections (two webs), formed by riveting two channel



This substructure view of a typical bridge from the Kirkham era, shows a pair of outer concrete girders, inner steel stringers, and standardized piers and railings.

sections with a top cover plate and. with batten plates or lacing or lattice bars along the bottom flanges. In defense of his design, Kirkham responded that "[a]bout twenty years ago, as I recall, I was about the first to bring out pony truss bridges with box sections." At the time, it was his belief that, by using the box sections for the upper chords (typically two channel sections riveted with top cover plate and lacing bars), the side stiffening brackets could be omitted. Experience showed, however, that the shop work did not provide straight top chords and the side brackets had to be added anyway. As a result Kirkham "was unable to see why a single web system was not preferable to trusses having box sections as quite a saving in metal and shop work is obtained." Kirkham claimed his pony trusses weighed almost one-third less than those of the Bureau of Public Roads, resulting in a savings in materials of about $1,000 for each 60-foot truss.

In defense of his design, Kirkham sent the Bureau of Public Roads evidence showing that his design was superior in supporting transverse horizontal forces, horizontal thrusts at the top chord, transverse loads at the mid-point of the verticals, and railing impact. Kirkham also suggested his design was superior because it allowed a thinner concrete deck, yielding additional savings. Kirkham objected to the Bureau of Public Roads design because the railing posts at the end of the span extended down to form "the basis of the shoe and consequently any severe impact from traffic at the top of this post is very apt to wreck the end bearing and besides, throwing [sic] a very heavy strain on the end posts." The standard South Dakota SHC pony truss had concrete approach guards to protect the ends of the truss. The guards also held the fill and prevented traffic from running off the top of the abutment. "This railing [approach guard] on our abutments is part of our pony truss design and is designed to harmonize with the type of truss and vice versa." Kirkham summarized: "In regard to erection, our truss is far superior to the truss proposed by the Bureau of Public Roads. It is also far superior, we think, from the standpoint of aesthetics when combined with the concrete railing." A number of these standardized SHC pony trusses with vertical end posts and concrete approach guards survive on the South Dakota landscape.

Of the 500 bridges constructed in 1923, the Annual Report listed several bridges worthy of special consideration, including the 336-foot Big Sioux River Bridge at Sioux City, which was "a special viaduct type" built entirely of concrete and capable of carrying 40-ton loads. Other noteworthy bridges included the Big Sioux River Bridge near Brandon consisting of three 60-foot arch spans; the 300-foot bridge over the Cheyenne River at Cascade Springs in Fall River County constructed with concrete piers and wood Howe truss spans; and a 408-foot concrete/steel viaduct over the James River at Forestburg, Sanborn County, constructed by the state. The Annual Report for 1928 provided the last listing of the Bridge Depart-

ment's statewide accomplishments as the Department began to focus its attention on bridging the Missouri River.

During the design and construction of the Missouri River bridges, the SHC Bridge Department reached its maximum staffing, continuing to provide designs for small bridges, the total value of which annually exceeded that of the larger bridges. Design and construction of the Missouri River bridges was Kirkham's last major task at the SHC. Kenneth Scurr recalled that, after the Missouri River projects, Kirkham "seemed a little lost without the big challenge that he had faced during the early years and his interest strayed to other fields." Kirkham finally resigned in 1928 "after a squabble [with the SHC over some] real or fancied interference in his department."

Kirkham retired briefly to Texas where he raised oranges with his son. He then became a research professor in civil Engineering at the Oklahoma Agricultural and Mechanical College. After about ten years, he again retired, this time to Omaha, Nebraska where he assisted his son in establishing the consulting firm of Kirkham-Michaels.

Missouri River Bridges

The area in South Dakota west of the Missouri River, called the "west river country," remained largely unsettled through most of the 19th century. The most significant 19th-century settlement in the region occurred in and near the Black Hills as miners were attracted by prospects of gold and as fanners and businesses were attracted by the prospects of supplying the miners. After statehood in 1889, the federal government began to open large sections of the Great Sioux Reservation west of the river to homesteading. As one of the last frontiers in the United States to be opened for settlement, the west river country attracted those who hoped that industrial technology would help them wrest a living from the semi-arid plains. When the Milwaukee Road and the Chicago & North Western extended their lines west to Rapid City in 1905, the boom in west-river settlement surged as homesteaders rushed to take up more Indian lands. Between 1900 and 1915, 100,000 newcomers settled in the region. Yet at the end of the First World War, the Missouri River still divided the state in half, with the railroad bridges remaining as the only all-season crossings.

Despite the lack of permanent bridges, Dakotans devised means of crossing the Missouri that changed with the seasons. During summer months licensed entrepreneurs operated ferries. As cold weather approached, the ferries were taken out of the river as ice floes began to

threaten the boats and cables. For about three months in most winters, the river froze allowing relatively convenient crossing. Spring thaws and high water brought several more months when ferry travel was impossible or hazardous. Even during the summer months, low water and shifting sandbars often made river crossing frustrating. In the 1890s, entrepreneurs began installing seasonal pontoon bridges in the river as well. These were costly and cumbersome affairs. The Pierre-Stanley pontoon bridge was 1800 feet long and rested on 120 boats linked by a cable. Additionally, every third boat was anchored to the river bottom by a 3-ton rock. The Pierre-Fort Pierre pontoon bridge was more than twice as long. These structures attracted many users, but had to be taken out each fall before the river froze.

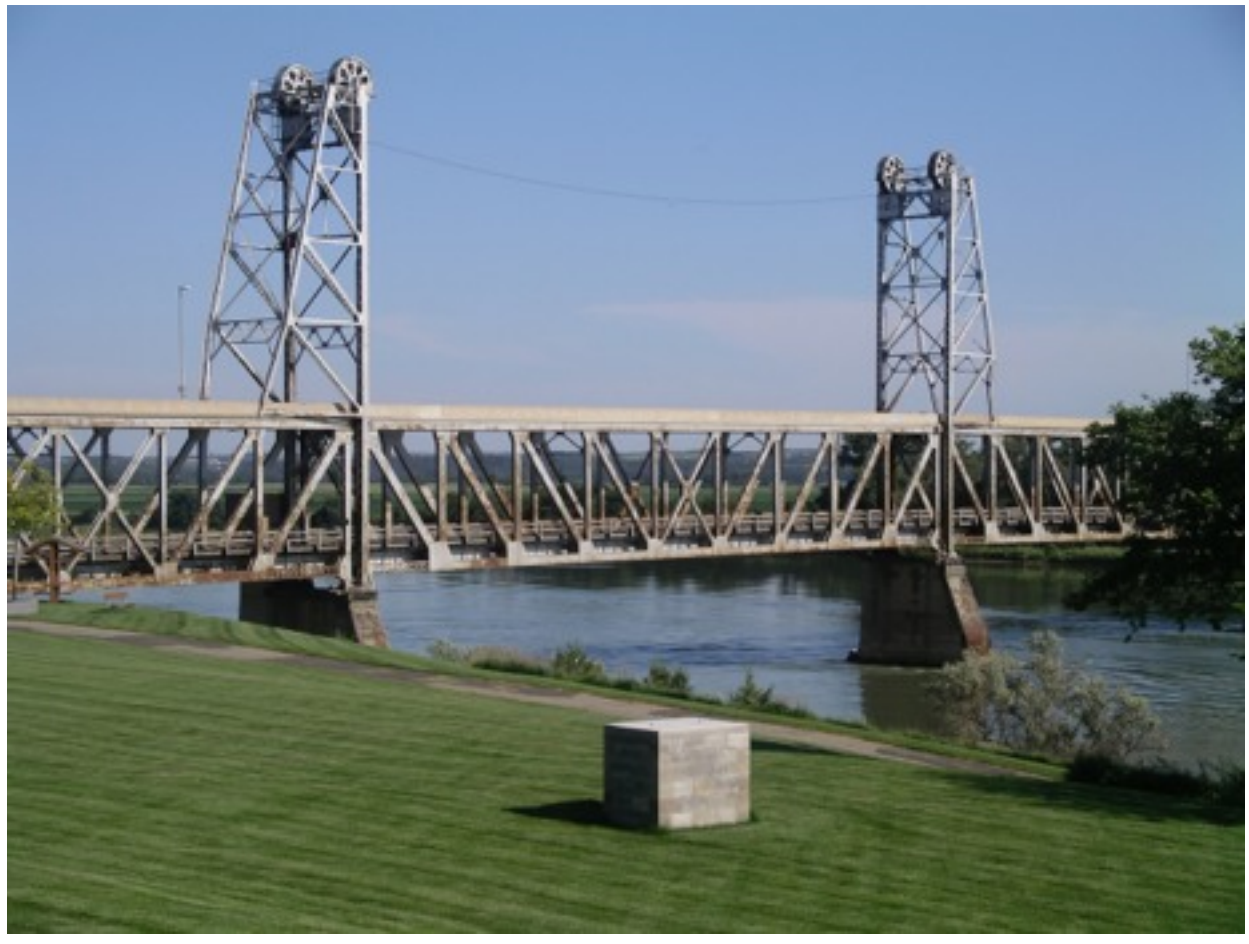
In 1919, with the ending of the First World War and significant populations on both sides of the river, Governor Peter Norbeck began lobbying for a small annual tax for the purpose of building bridges across the Missouri River. He was supported by those organizations and individuals who recognized the Missouri River as effectively dividing the state into two halves, hampering commerce between the two sides of the state. In 1921, the South Dakota Legislature passed a bill levying a tax of one-tenth of a mill on all taxable property for the purpose of funding the construction of three Missouri River bridges. It was believed at the tine that it would take twelve years to raise enough money for the bridges.

While state government worked to raise the necessary revenue to build bridges to link the two halves of South Dakota, the first highway bridge to be constructed over the Missouri River in South Dakota connected Yankton with Nebraska to the south and was privately financed by the Meridian Highway Bridge Co. of Yankton. The bridge drew its name from the Meridian Highway, an internationally organized route linking Mexico City with Winnipeg. Yankton business interests had organized a private bridge company in 1915, but the war effort interrupted their plans. In 1919, a new company was formed and began running full-page advertisements in the Yankton Press and Dakotan boosting the benefits of linking Yankton to Nebraska and promoting the purchase of stock in the company. The articles predicted Yankton's population would increase from 100-500 percent, that railroads and "hard surface" roads would cane to Yankton from all directions, and "general prosperity will be in our midst." By January 1920, the company had retained bridge engineers Harrington, Howard and Ash of Kansas City to design the bridge, which was to include provisions for both highway and rail traffic and also wells in the piers to provide city water. Established in 1914 with John Lyle Harrington as senior partner, the engineering firm was especially well regarded for its designs of movable bridges. While in a previous partnership with the nationally renowned bridge engineer J.A.L. Waddell, Harrington had helped develop an

important moveable bridge type that is still known as the Waddell and Harrington Vertical Lift, of which the Meridian Bridge at Yankton is an example. The vertical lift capability of the bridge allowed unrestricted navigation on the Missouri River.

Construction began on the Meridian Bridge in 1920 when the Missouri Valley Bridge and Iron Company was awarded the contract for the substructure. Due to delays in raising the necessary capital, construction of the superstructure did not begin until 1923, when the Kelley Atkinson Company of Chicago was awarded the construction contract. The American Bridge Company fabricated the bridge steel. The bridge was completed in 1924 and the vertical lift span was raised for the first time that July. Although the lower deck was equipped with tracks, the anticipated rail route never materialized and the bridge has remained solely a highway bridge. After twenty years, the shareholders in the Meridian Bridge Company had only realized a two percent return on their investment. They sold the bridge to the City of Yankton in 1946. After it had recovered the purchase price by collecting tolls, the city opened the bridge free to users in 1953, the same year the lower deck was converted to accommodate highway traffic.

As construction of the superstructure of the Meridian Bridge was getting underway in 1923, the state's bridge fund had accumulated $400,000. Delegations from Rosebud, Chamberlain, Pierre, Forest City, and Mobridge appeared before the legislature that year, each requesting a bridge



The Meridian Bridge, Yankton.

at its respective location. Kirkham created quite a sensation in the press, and favorable publicity for himself, by insisting that he could build five Missouri River bridges for $2 million. Skeptics pointed to a combination railroad-highway bridge constructed across the Missouri River between Bismarck and Mandan, North Dakota in 1920-22 at a cost of $1.3 million. The Meridian Highway Bridge Company was also preparing to privately finance its $1.4 million bridge at Yankton. Years later, Kenneth Scurr pointed out that the proposed South Dakota highway bridges could not be fairly compared to the other two examples because they were designed to carry railroad traffic and had to bear the cost of private financing. The press, however, did not make such distinctions. Kirkham based his claim on his own preliminary plans and estimates in which he sought economy by exploiting local conditions at each site. Kirkham's estimates, notwithstanding the comparisons he allowed the press to use, proved accurate: the total construction cost of the five Missouri River bridges totaled $2.1 million.

With Kirkham's figures in hand, the 1923 legislature appropriated funds for the Missouri River bridges and developed a mechanism to determine the order of construction by joint legislative caucus. Each senator and representative was asked to vote in descending order his preference for the order of construction of all five bridges. The vote established that the Wheeler bridge (originally known as the Rosebud bridge) was to be constructed first, followed by the bridges at Pierre, Chamberlain, Mobridge, and Forest City. Fearing a delay in construction of all of the bridges if the order of construction were to be put before the voters in a referendum after those drawing the last places expressed their dissatisfaction, the Legislature amended the bill so that any community could advance from its order by issuing bonds or tax anticipation warrants covering 58 percent of the cost of the bridge at its location, to be retired by the bridge mill levy as funds became available. The Mobridge and Chamberlain bridges advanced out of their original order by taking advantage of this particular provision.

The designs of the five Missouri River bridges were similar, with minor variances due to local sub-surface conditions. Scurr stated that the superstructure design of the bridges was really dictated by the Corps of Engineers Navigation Requirements, which required a clear span of 250 feet and clearance of 38 feet above high water. “The arrangement of spans within these criteria was the result of adhering to the classic principle of economical bridge design; that maximum economy is achieved when the cost of the foundations is equal to the cost of the superstructure less the floor system.” Scurr recalled that Kirkham was especially pleased with his sub-structure designs, often referring to the foundations as “patentable original designs. He knew they were not [patentable] but it made good copy for the newsmen. . . . The excellence of the designs lay in the very in-

telligent use of all engineering principles and not in any innovative breakthrough." The following is a brief description of each of the five bridges:

- The Mobridge Bridge, comprised of five 256-foot riveted Pennsylvania through truss spans, was the first of the five Missouri River bridges completed on November 12, 1924. The bridge was built by the Minneapolis Bridge Company in ten months. The American Bridge Company fabricated the steel.

- The Wheeler (Rosebud) Bridge, comprised of six 256-foot pin-connected Pennsylvania through truss spans and completed in September 1925, was the only pin-connected bridge among the five. Kirkham designed it for disassembly because of the possibility that it might be replaced with a combination railroad/highway bridge. The bridge was built by the Kansas City Bridge Company with steel fabricated by the American Bridge Co.

- The Chamberlain Bridge, comprised of four 336-foot riveted Pennsylvania through truss spans and completed in September 1925, was built and fabricated by the Missouri Valley Bridge & Iron Works of Leavenworth, Kansas.

- The Pierre Bridge, comprised of four 300-foot and two 336-foot riveted Pennsylvania through truss spans, and completed June 26, 1926, was fabricated and erected by the Lakeside Bridge & Steel Co. of North Milwaukee, Wisconsin.

A postcard view of the Chamberlain bridge, soon after completion.

- The Forest City Bridge, comprised of four 256-foot and two 300-foot Pennsylvania through truss spans, and completed in May 1927, was fabricated by the St. Louis Structural Steel Company and constructed by R.L. Gaster & Company of Little Rock, Arkansas.

The five Missouri River Bridges built by the SHC and the Meridian Bridge were all completed during a period which saw significant construction in spanning the Missouri. During the 1920s comparably large projects were completed at Bismarck/Mandan and at four sites in Missouri. All of the bridges except the Bismarck/Mandan Bridge and the Meridian Bridge employed Pennsylvania trusses. Yet, four of South Dakota's five Missouri River Bridges were to serve for only two decades (The bridge at Pierre was abandoned in 1962 but stood until 1986). Kirkham's prediction at the dedication of the Mobridge Bridge that, barring a disaster, it would carry traffic for five hundred years was thwarted by the U.S. Congress. In 1944, Congress passed the Flood Control Act, funding the construction of four dams on the Missouri River in South Dakota. The resulting reservoirs required that four of the Missouri River bridges be replaced. Spans of the Chamberlain and Wheeler bridges, however, were used to create a new bridge at Chamberlain in 1953.

Later Evolution of the State Highway Commission

Following the completion of the Missouri River bridges, the SHC Bridge Department continued providing bridge designs for the state and counties. At the time of Kirkham's resignation in 1928, only two of his former students who where original staff members remained. Harper Hamilton succeeded Kirkham to the position of Bridge Engineer and Kenneth Scurr became Assistant Bridge Engineer. In 1931, Scurr became Bridge Engineer and served in that position until 1963. Bridge construction in South Dakota decreased steadily from 1923 until the beginnings of the Great Depression when it practically ceased altogether. The Bridge Department staff, which had included thirteen engineers during the design and construction of the Missouri River Bridges, was reduced to five engineers by 1928 and to three engineers by 1933. The decline through the 1920s was partly due to the fact that most of the counties had completed their major bridges. During those latter years, the Bridge Department concentrated on effecting economies in the structural design of small bridges and culverts.

Former governor and U.S. Senator Peter Norbeck continued his visionary support of the SHC Bridge Department through the 1920s and 30s. After construction of the Missouri River bridges, he turned his attention to attracting tourists to the Black Hills. Norbeck had been working to estab-

lish and then improve a great park in the Black Hills since 1905. One of his projects, the construction of the "pigtail bridges" on the Iron Mountain Road, was undertaken by the SHC Bridge Department in cooperation with the Custer Park Board and the U.S. Forest Service. Built in a rustic style of Black Hills pine, the pigtail bridges were integral to a design scheme in which the roadway spiraled back over itself, enhancing the picturesque qualities of the setting. The bridges became the second most photographed feature in the Black Hills, after Mount Rushmore.

By the 1950s, the pigtail bridges were deteriorating, am the SHC Bridge Division was given the job of devising a method for their preservation. Concrete was poured around the piles to prevent moisture penetration and steel I-beams were placed between the log stringers to reinforce the deck. Rotting timber in the deck, curbs, and rails was also replaced. Today, only one pigtail bridge survives from that 1950s repair effort. All of the others have been subsequently rebuilt so that, although they still function as pigtails and they have many wood structural elements, their appearance is somewhat different from the originals. The surviving example now has steel stringers installed in 1950, but the outside stringers are faced by half-cut logs which, in conjunction with the log substructure and log railings, leave the bridge looking much as it did when first built in 1930.

Another idea credited to Norbeck is the construction of two tunnels through Iron mountain to provide tourists with framed views of Mount Rushmore. The pigtail bridge just described gains added significance by its proximity to one of the tunnels. Ascending the approach and crossing the bridge, one immediately enters the tunnel on axis with a view of Mount Rushmore. Scurr stated that although the pigtail bridges and tun-

An early postcard view of one of the pigtail bridges on the Iron Mountain Road.

nels cost much more than standard highway construction at the tine, the state felt the investments a worthy attraction for tourists.

Norbeck's keen sense of creating vistas to delight tourists is also reflected in the open-spandrel concrete-arch Beaver Creek Bridge on the Wind Cave Road. Typical construction design would have called for a box culvert, but Norbeck had the highway engineers design the bridge and approaches so that the dramatic open-spandrel structure would be visible to approaching motorists from a quarter of a mile away. The open-spandrel concrete arch was used widely during the 1920s and 1930s in such places as Minneapolis to cross the Mississippi River and Oregon along the Coastal Highway, but the Beaver Creek Bridge is the only example of the structural type known to have been built in South Dakota.

NewDeal Programs

Bridge construction in South Dakota resumed in the mid-1930s under President Franklin D. Roosevelt's New Deal programs. Almost immediately after Roosevelt took office in early 1933, Congress began passing legislation to implement his recommended relief measures, and by September of that year, federal officials were meeting in Pierre to plan highway projects for South Dakota to be undertaken with federal assistance. In general, the federal agencies paid for labor, while the state or local highway departments paid for supervision, engineering, and materials. Kenneth Scurr identified two trends in county bridge construction resulting from the re-

The construction of the Beaver Creek bridge.

quirement that the sponsor provide the materials to match the federally financed labor. The intent, of course, was to put as many men to work as possible with minimal investment on the part of the financially strapped local governments. Counties often re-used materials to construct new bridges that would not have been economical to adapt without the subsidized labor. For new construction, concrete bridges were popular because they generated more labor-intensive projects than steel bridges.

In anticipation of a South Dakota's share of a federal Works Progress Administration appropriation of $250 million to $300 million for 1935, Scurr wrote Andrew Norstad, secretary of the SHC, explaining that South Dakota would be capable of handling the program with a much smaller staff than the adjoining states:

> *... our plans are drawn with the absolute minimum detail and are not as elaborate as ... adjoining states where much larger forces are used. The Bureau of Public Roads and the contractors and steel companies involved have indicate[d], however, that they are adequate, and we do not contemplate any change in this policy.*

Because the SHC's capability to undertake the influx of work required the “utmost of cooperation and loyalty" among his staff, Scurr recommended that salaries be raised to levels comparable with adjoining states in order to ward off a raid on his employees as other states began to increase their staffs.

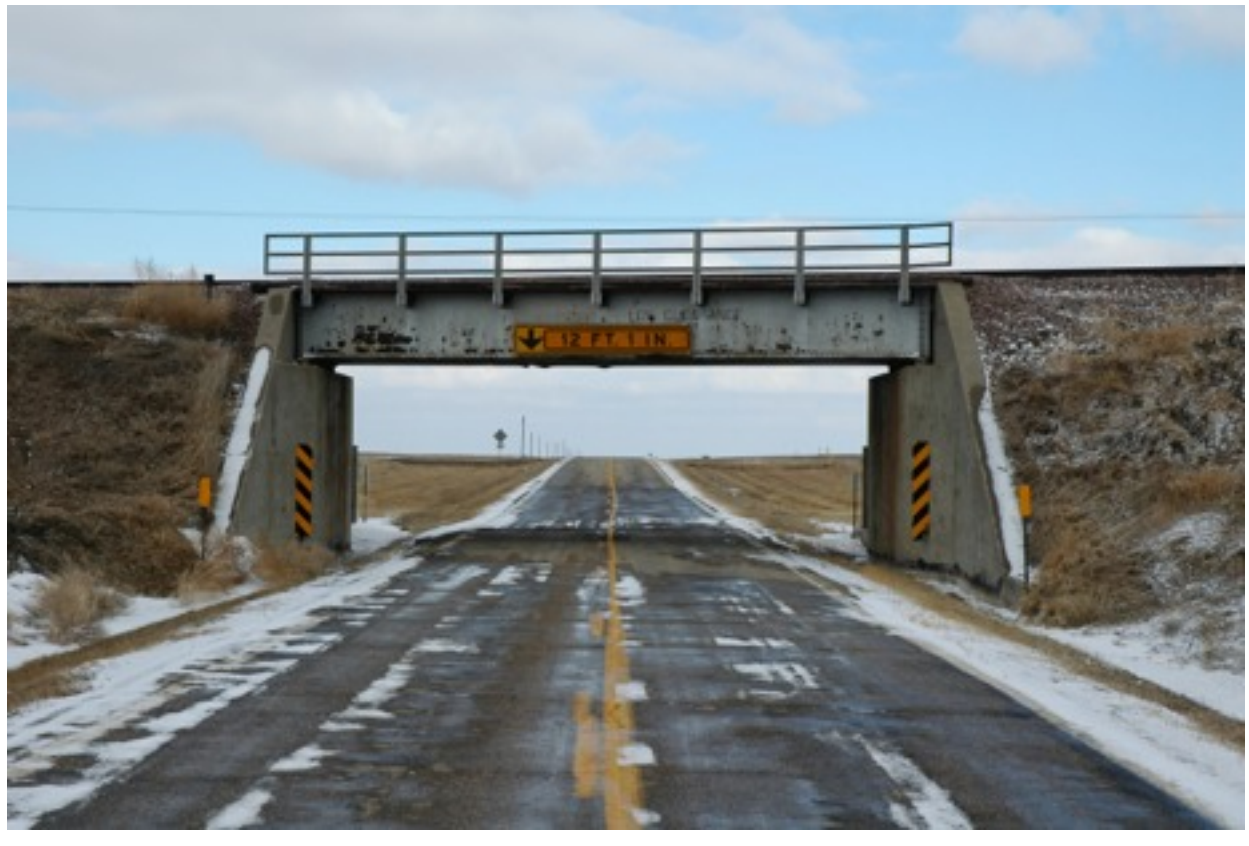
With the Hayden-Cartwright Act of 1934, Congress initiated a program for immediate highway construction projects. “The elimination of traffic hazards, particularly those caused by railroad grade crossings” received second priority in the list of eligible projects. Deaths at railroad crossings were a serious problem that had been publicly debated since the beginning of the 1900s. Nearly 4000 deaths at railroad crossings were recorded in 1902; that figure increased to nearly 14,000 in 1921. Railroad companies tried a wide assortment of mechanical and electrical safety devices at the crossings without successfully reducing accidents. In trying to gain an understanding of the psychology of motorists who ignored crossing signals, studies showed that fewer than ten percent stopped, looked, and listened when they encountered crossing signals. This led planners to recognize the need for a more costly solution: grade separations.

In South Dakota, with its wide treeless prairies and straight, fairly level roads, the frequency of crossing fatalities would not have reached those levels found in more hilly, vegetated rural areas or urban centers. Still, about 30 grade-crossing elimination projects were undertaken under the federal program. Two of the projects on U.S. 12 crossing the Chi-

cago, Milwaukee, St. Paul & Pacific Railroad tracks in Brown County are representative of the type of structures built. The steel I-beam viaduct designs with concrete balustrades are very similar to the designs recommended by J. E. Kirkham for low flat crossings in his 1932 book, *Highway Bridges: Design and Cost*.

The public works projects, emphasizing labor-intensive projects, resulted in sane very finely designed and crafted bridges. One of the most picturesque is the multi-plate-arch bridge over the Big Sioux River in Watertown. Designed by the SHC in 1935, the bridge was constructed as a U.S. Public Works Highway Project and measures 111 feet in length. The graceful five-span arch structure is faced with uncoursed gray and pink granite, designed not only to carry traffic, but also to be an ornamental landscape feature in its city park setting.

Federal assistance during the New Deal also went directly to the counties in the form of relief assistance, in which the counties generated works projects for people who were out of work. This money no doubt found its way to local bridge projects throughout the state, but the legacy surviving in Turner county stands out. Because of the availability of good building stone and skilled masons in the county, relief organizers employed crews under the direction of a bridge foreman to build stone-arch bridges to replace old wood structures and also to build stone abutments under existing steel bridges. Crews built reusable centering for constructing arches six, eight, and ten feet wide and used the centering for building single-, double-, and triple-arch bridges. The bridges were designed without parapets or railings so there would be no obstacles to hamper snow re-



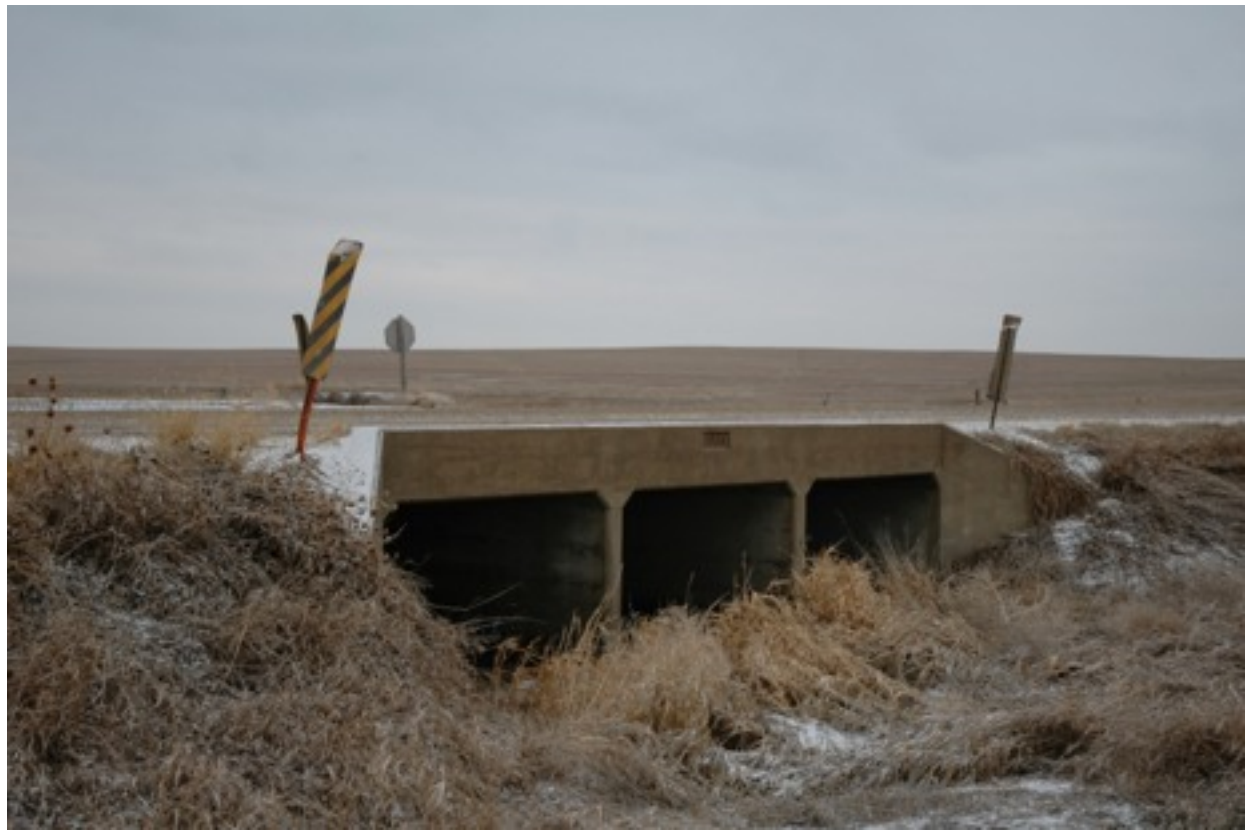
A New Deal-era underpass below the former Milwaukee Road main line, in Walworth County.

moval. As is visible by the angled guards at each end of the bridge, designs for the abutments were based on the standard SHC designs, with stone used instead of concrete.

The use of stone and subsidized labor allowed Turner County to build bridges at one-fourth the cost of comparable steel or concrete structures. Reportedly, the use of stone had the added advantage of providing less tedious work for the relief workers than building conventional bridges. Between July 1934 and September 1936, Turner County built 65 stone bridges and continued to build them through the end of the New Deal era. The Turner County Highway Department maintains records on 180 stone-arch bridges that survive, all of which were built during the period. Spring Valley Township Bridge No. E-31 is the longest of the surviving stone-arch bridges in Turner County, consisting of three 10-foot spans.

Minnehaha is the one other county in which federal assistance during the 1930s is known to have led to a true stone-arch bridge. In 1935, the City of Garretson received approval for its first WPA project. The appropriated $23,000 paid for raising an existing dam across the Split Rock River four feet, building a supplemental dam downstream, constructing a stone bath house, erecting an ornamental entrance to Split Rock Park, and building a stone-arch foot bridge. Crews completed the bridge in the fall of 1936. Consisting of four 9-foot 6-inch spans, the Split Rock Park Bridge was built by local laborers supervised by a stonemason from Sioux Falls.

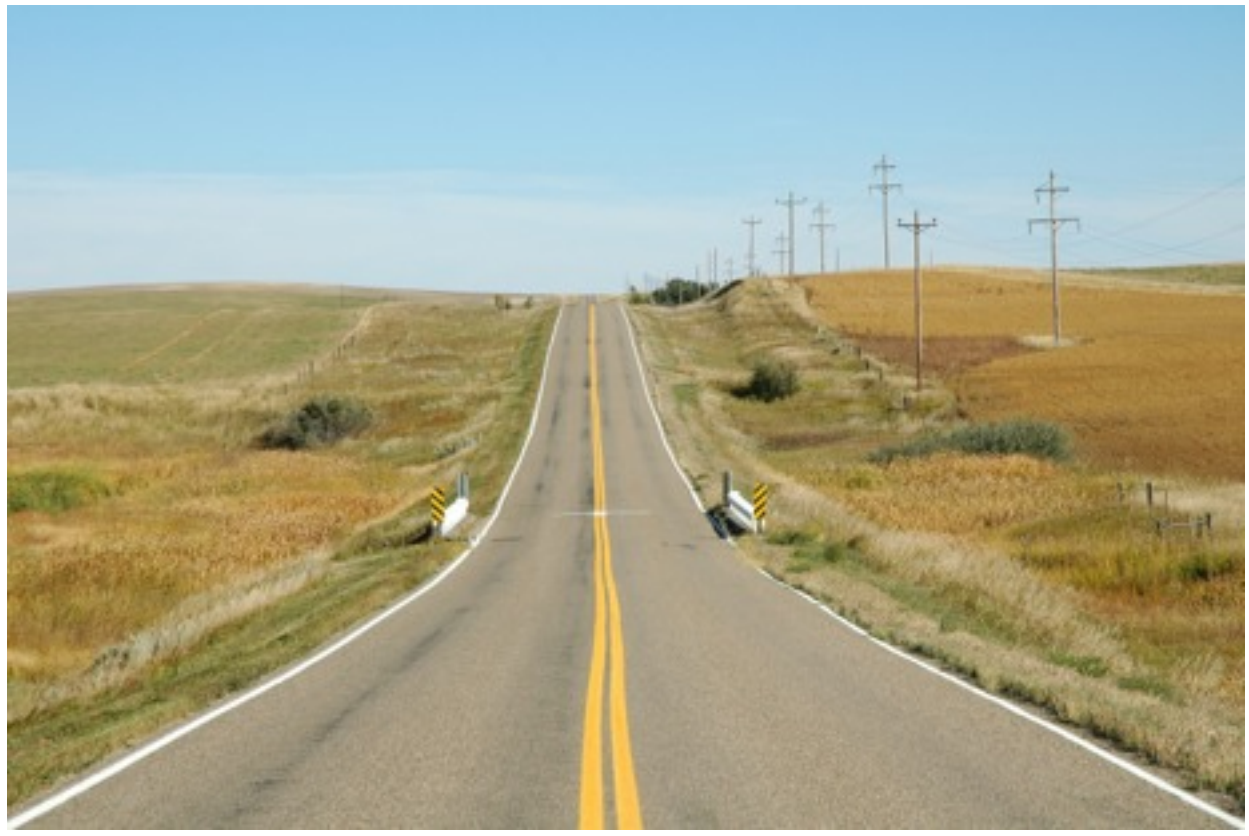
Another important New Deal bridge project in Minnehaha County also included stone masonry. The riveted lattice through truss over

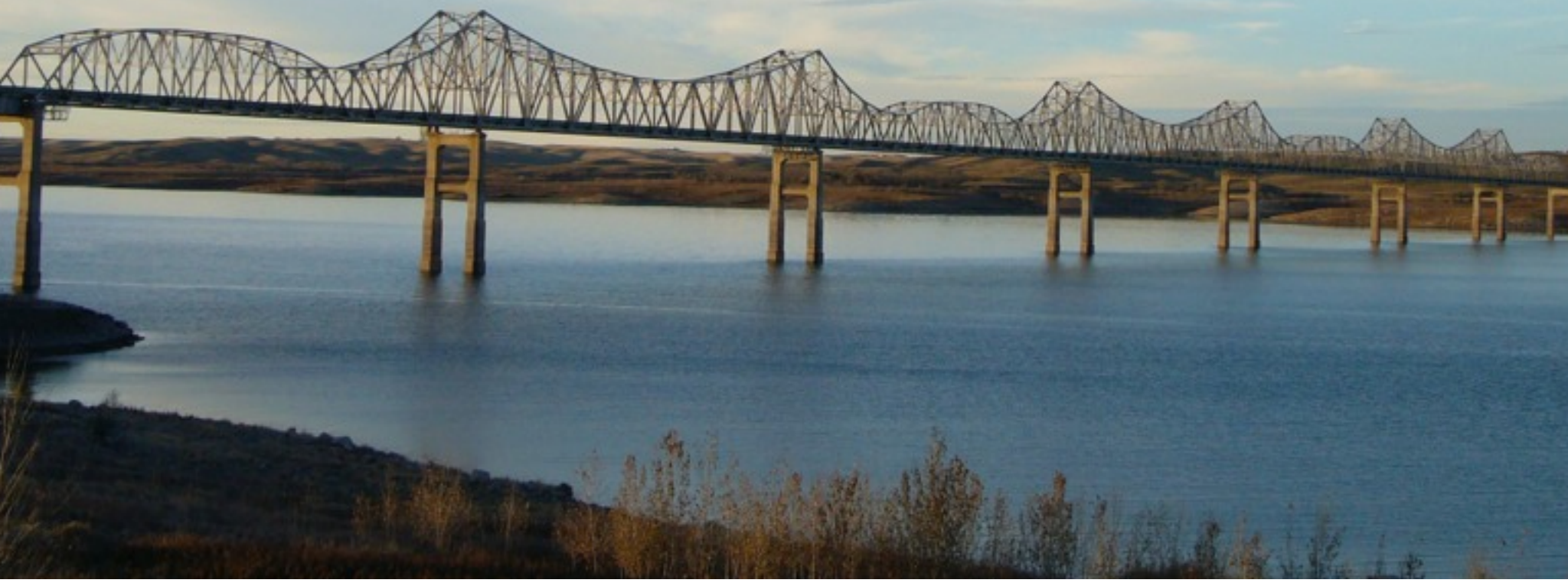


A typical three-barrel concrete box culvert from the 1930s.

the Big Sioux River south of Dell Rapids is a former railroad bridge, typical of those built by the Chicago, Minneapolis & Omaha in Minnehaha County in the late 19th century. The concrete abutment at the north end of the bridge shows evidence that the present, adapted railroad superstructure is not the first span at this location. The south abutment is stone masonry typical of that built during the 1930s.

As it became evident that the United States was preparing for entry into World War II, the SHC construction programs again diminished. At the same time, Kenneth Scurr undertook a survey of inadequate bridges in South Dakota. He estimated that the state had approximately 2200 bridges. Of them, 1478 did not meet current requirements for loading and/or width. Scurr took a leave of absence from the SHC Bridge Department to serve in the South Pacific during the Second World War. Phil Schultz, Assistant Bridge Engineer, served as Acting Bridge Engineer during the war. The only bridge constructed during the war was a concrete bridge leading to the bombing range at Red Shirt, associated with what is now Ellsworth Air Force Base near Rapid City.





6

WORLD WAR II AND BEYOND

The World War II Years

In South Dakota and throughout the United States, the state-sponsored bridge-building and highway construction programs that had flourished during the 1930s ground to a near-total halt with the advent of World War II. As the nation expressed its patriotism by devoting all possible resources to promoting the war effort, the South Dakota State Highway Commission was forced to curtail both capital projects and more routine programs. The Commission's 1943-1944 "Annual Report," for example, noted that its annual receipts had dropped to 64% of the amount received in 1940-1941. Simultaneously, mili-

tary service and work at defense plants had called away many highway workers, and the Commission was hard-pressed to fill its employment rolls. Equipment and materials shortages caused by the war also had a significant impact, as the Commission had difficulty obtaining vehicles, gas and oil, and construction supplies. Federally-imposed wartime restrictions were also placed on highway construction projects nationwide.

Combined, these war-related difficulties forced the State Highway Commission to drastically scale back its operations between 1942 and 1946. Only one state-sponsored bridge is known to have been constructed during those years – a concrete span crossing the Cheyenne River southeast of Rapid City, and accessing a newly designated Army Air Force bombing range. Major cutbacks in county-sponsored bridge constriction activity also occurred, with only urgent bridge replacement projects being considered. The Commission, working with a reduced force of engineers during the war, busied itself instead with future planning for the revitalized highway and bridge construction programs that it was certain would follow the war's end.

A Reborn Bridge Program, 1946-1949

As World War II came to a close in the summer of 1945, the South Dakota State Highway Commission was eagerly awaiting the promised rebirth of both its highway and bridge construction programs. That June, the Commission's "Annual Report" reflected the agency's sentiment with the happy observation that:

As the light of victory creeps into the sky of today and peace may soon cover our land, the business confronting a highway department will bestir itself as the rustle of singing birds in the dawn of a new day. This will surely be music to the ear of the motorist and the response given by the highway industry will be a paramount issue with this motorist.

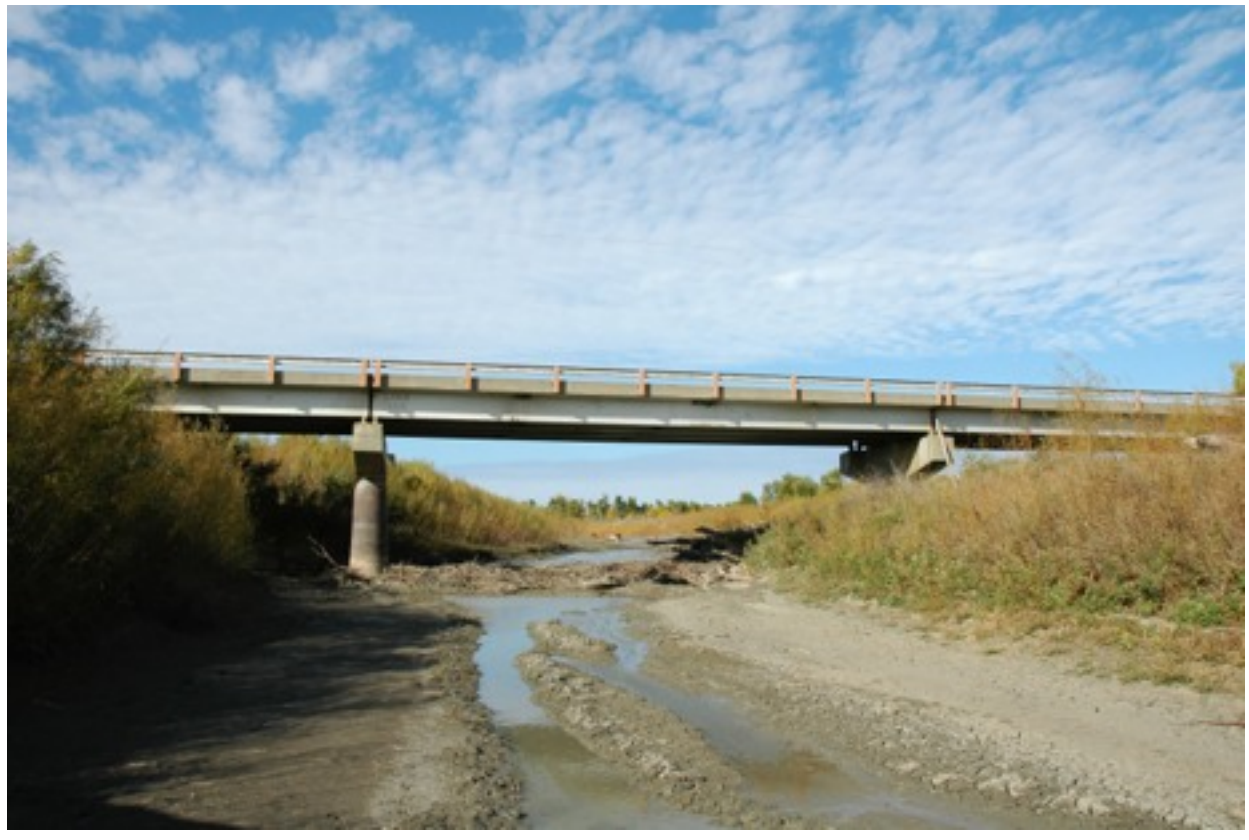
The federal restrictions that limited wartime highway construction work were lifted shortly after V-J Day, and the Highway Commission began working quickly to clear its four-year backlog of highway and bridge improvement projects. With the assistance of funding provided by a new federal "Post-War Program," the state resumed bid letting in December 1945, so that construction work could resume in earnest during the 1946 summer season. Development and implementation of the projects was generally rapid, although the Commission complained of a post-war shortage of qualified engineers, particularly in the Bridge Department. Even so, by mid-1946 the size of the Bridge Department workforce had increased from

Previous page: the Forest City bridge across the Missouri River at Lake Oahe, completed in 1958.

two to eleven, reflecting both increased federal funding and the state's demand for new roadway bridges.

Throughout the remainder of the 1940s, the enlarged Bridge Department staff continued to design Federal Aid bridges for county and state roads, new grade separation structures, and a number of major, prioritized spans for the state system. The construction process for many of the new spans often proved difficult for the state, however, due to continued labor shortages, high post-war construction costs, and continued shortages of steel and other critical building materials. A number of major state bridge projects were delayed or postponed as a result, and county-sponsored bridge projects comprised the bulk of the Bridge Department's work.

The lingering post-war material shortages, combined with evolving bridge construction philosophies, resulted in gradual yet visible changes in the types of bridge designs employed in South Dakota. Relatively few truss bridges had been erected in the state since the 1920s, and after World War II almost no truss designs appeared on Bridge Department drawing boards. The stringer and girder configurations that replaced the truss became appropriate for all but the longest applications, and this bridge form soon became nearly ubiquitous. Steel shortages in the late 1940s helped continue the interest in reinforced concrete as a building material, although concrete girder and beam bridges continued to be outnumbered by their steel counterparts. Culverts and other small precast structures also became more common, both as a way to reduce building costs and as a response to continuing shortages of certain construction components. Still



This 1960s-era steel girder bridge in Dewey County is a typical representation of the standardized bridge designs of the era.

other changes included increased deck widths and a trend towards simpler, less-ornamental guardrailings.

The Korean War and the New Missouri River Bridges, 1950-1953

Just as the South Dakota Highway Commission's bridge construction efforts slowly began a return to normalcy in the late 1940s, a series of new events again necessitated changes in the program. The Korean War (1950-53) brought renewed concerns about personnel and supply shortages, although the resultant impact was far less severe than that felt during World War II. A more dramatic and immediate concern for the state's bridge engineers, however, was the construction of a series of four massive dams across the Missouri River in South Dakota. The dams, constructed by the Army Corps of Engineers and authorized under the federal Flood Control Act of December 1944, resulted in the inundation of nearly all of the state's Missouri River bottomland, and flooded the sites of four of river's five state-constructed highway bridges. The Highway Commission and Corps of Engineers developed a joint program to replace roads and bridges flooded by the new dams, and the results included South Dakota's most dramatic and significant transportation engineering projects of the period.

The impact of the Missouri River dam projects was keenly felt by the Bridge Division. By 1949, the Corps of Engineers had contracted with the Highway Commission to provide plans and specifications for the highway structures to be impacted by the new reservoir, and a separate "Missouri River Bridge Division" was soon organized to handle that work. While design and construction work on the new Missouri River spans continued into the early 1960s, the first three structures were opened to traffic between 1953 and 1959. Individually and collectively, they are easily the most significant mid-twentieth century highway bridges in South Dakota:

- The Chamberlain Bridge, completed in 1953, is a unique structure assembled from truss spans recycled from the dismantled highway bridges that had been constructed at Chamberlain and Wheeler in 1925. The structure includes ten such spans, five of which are used for eastbound traffic, and five for westbound.

- The Forest City Bridge and the Mobridge Bridge were constructed simultaneously between 1957 and 1959. Each of these structures is approximately 5,000 feet long overall, and features through-truss primary spans. The total cost of the two bridges was approximately

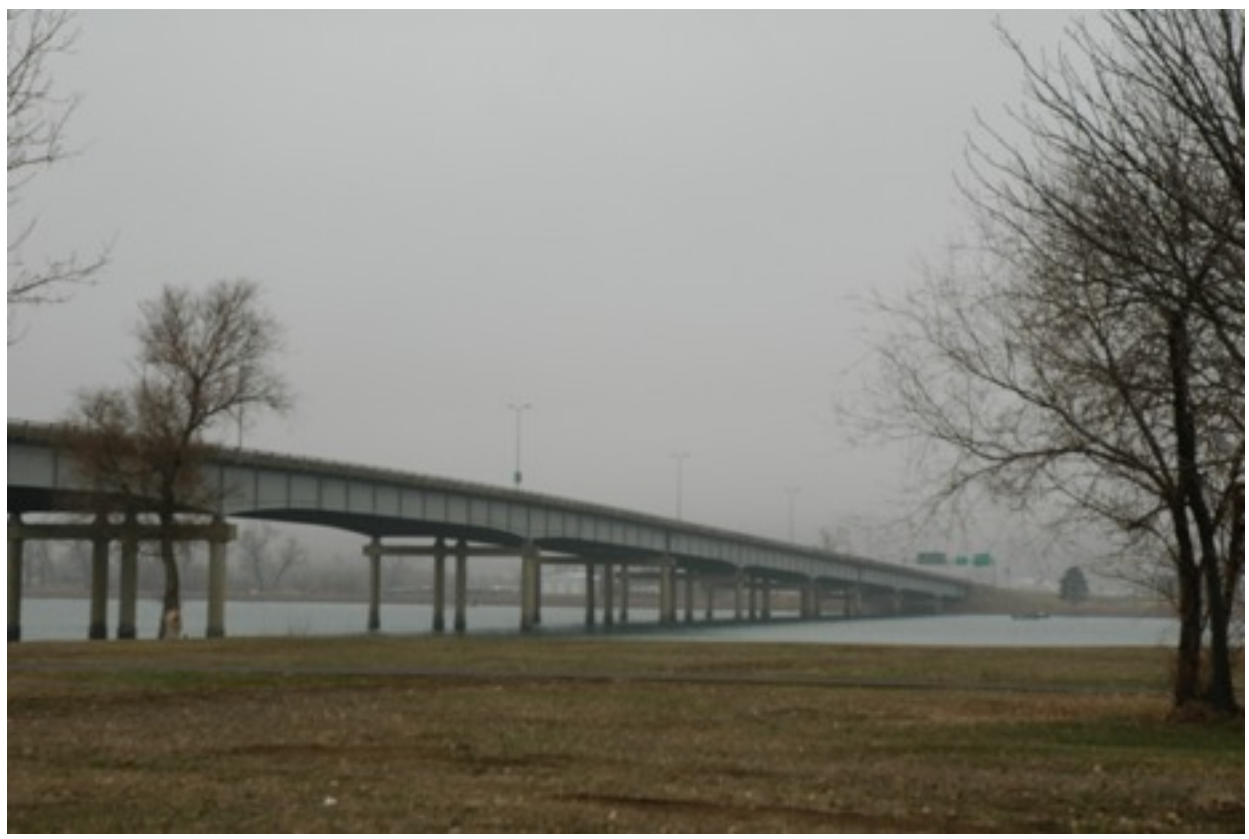
$9,000,000. These were the last truss bridges known to be constructed for highway use in South Dakota. On their completion, the state described these structures as "the largest long-span high bridges over inland waters in the United States. In magnitude they are only exceeded by the large government built dam projects."

Although federal funding was provided for the Missouri River bridges, all three were designed by the State Highway Commission, and constructed under state supervision. This was a point of no small pride to the state, especially given the relative size and complexity of the three projects.

The Beginning of the Interstate Highway System, 1954-1970

Both highway and bridge construction activity continued to increase in South Dakota throughout the 1950s. State bridge engineers continued work on projects related to the Missouri River dams, and supervised construction of an increasing number of spans for state and county governments. In recognition of the increasing size and complexity of the State Highway Commission's role in local transportation and commerce, the Commission was reorganized into a new "South Dakota Department of Highways" in 1956.

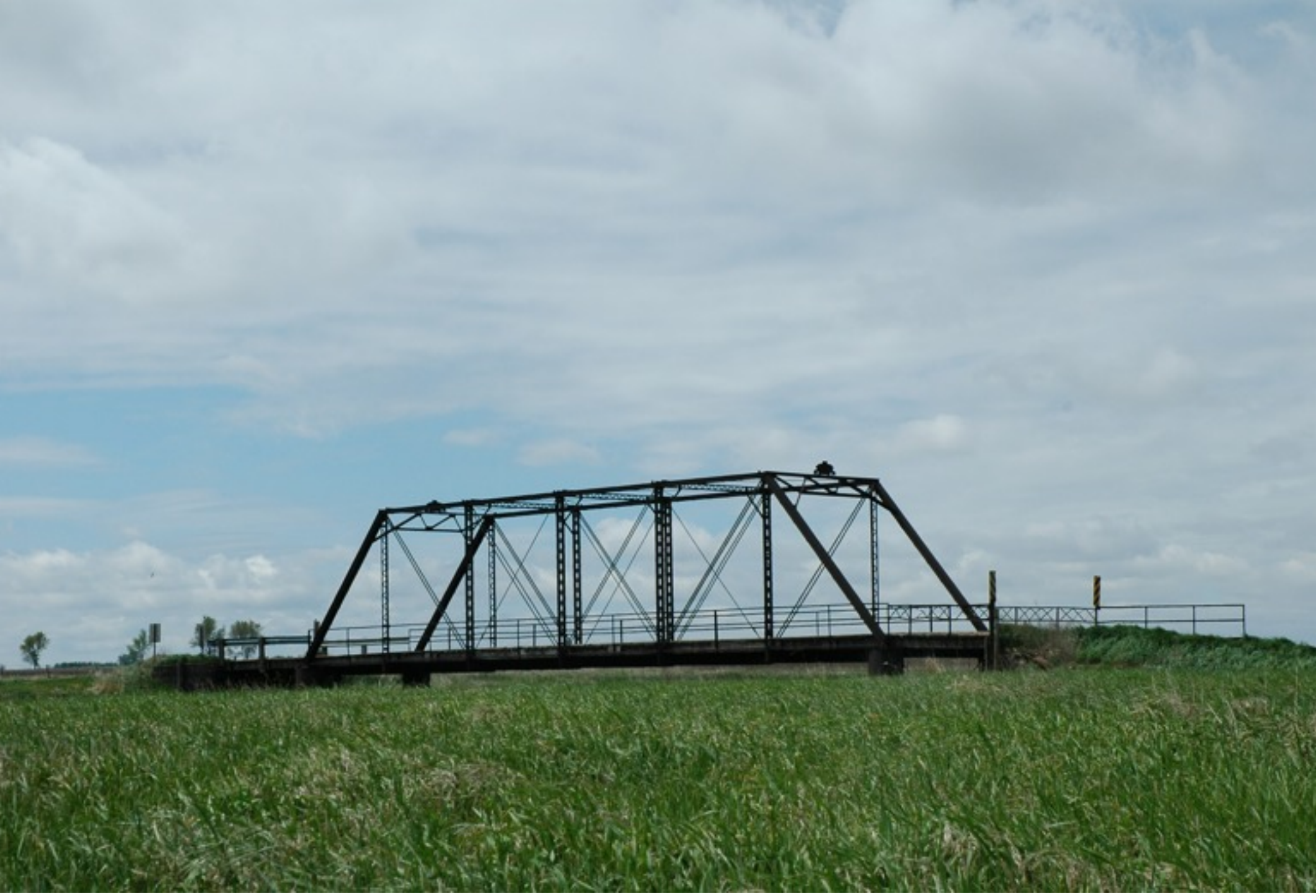
In common with the rest of the United States, highway and bridge improvement programs in South Dakota were dramatically impacted by



A wintertime view of the current Missouri River bridge at Pierre, completed in 1962.

the establishment of the Interstate Highway system. Authorized by Congress in 1956, the "National System of Interstate and Defense Highways" provided for a network of multi-lane, controlled-access roadways to be built throughout the 48 contiguous states. In South Dakota, Interstate 90 was planned for construction on an east-west alignment roughly paralleling U.S. Highway 16, and the route of Interstate 29 ran north-south near U.S. 81. Work on the first local segments of Interstate 90 was underway by 1957. The construction of South Dakota's Interstate highways continued into the 1970s, and necessitated the construction of literally hundreds of stream crossings, highway overpasses, and railway grade separations.

With the notable exception of the large, custom-designed structures erected across the Missouri and its reservoirs, roadway bridge design in 1950s South Dakota continued to reflect a long-term trend of simplicity and standardization. Most new bridges built were simple deck structures supported by steel girders or stringers, or by concrete girders or beams. New truss bridges, arches, and other unique structural types were all but unheard of. County and state bridges continued to reflect almost wholly standardized designs, with only minor variations as necessary for site conditions. The trend toward increasing use of structural concrete also continued, supported in part by the expense and lessened availability of bridge steel. The largest bridges of the 1950s and beyond – across the Missouri and on the Interstates – continued to utilize steel superstructures, but in the years to follow concrete girder bridges could be seen at almost any location in the state.



7

EPILOGUE

The story of South Dakota's settlement and development is inexorably tied to the history of travel across the territory and the state -- the planning, construction, and maintenance of the infrastructure needed to carry people and goods from one place to the next. South Dakotans have relied on a variety of transportation methods over the years, but for most of the state's history its expansive network of roads and highways has been the focus of both local and interstate travel. County and local governments have worked since the nineteenth century to construct and improve this infrastructure, and the State of South Dakota itself has been a key part of the effort for well over a century.

From the beginning, the construction and maintenance of roadway bridges has always been a central focus of county and state highway programs. The most expensive and challenging components of nearly any highway project, the state's bridges were also the key visual landmarks of the South Dakota highway network, monuments to the development of the region and striking contributions to the cultural landscape. As a group, the bridges are powerful, striking reminders of the planning and effort required to create the South Dakota that we know today.

South Dakota's roadway bridges remain as vital as ever today, and the cultural landscape of our highways continues do display an intriguing and impressive assortment of bridge types and styles. Though many of the state's oldest bridges have required replacement over the years, South Dakota's road network still retains numerous examples of exceptional historic bridge design, important and worthwhile landmarks to over a century of South Dakota travel.