NPS Form 10-900-b
(Jan. 1987)

OMB No. 1024-0018

UNITED STATES DEPARTMENT OF THE INTERIOR
National Park Service

NATIONAL REGISTER OF HISTORIC PLACES
MULTIPLE PROPERTY DOCUMENTATION FORM

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

A. Name of Multiple Property Listing

Historic Bridges in South Dakota, 1893-1942

B. Associated Historic Contexts

Historic Bridges in South Dakota, 1893-1942

C. Geographical Data

The State of South Dakota

[XX] See continuation sheet

D. Certification

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

Signature of certifying official — Date

State or Federal agency and bureau

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

Signature of the Keeper of the National Register — Date

HISTORIC BRIDGES IN SOUTH DAKOTA, 1893-1942

THE FIRST SOUTH DAKOTA BRIDGES AND THEIR BUILDERS

Prior to the early 19th century and the establishment of the European-American fur trade in South Dakota, the region's transportation network consisted of the trails and water routes of the Indians. The first trail documented in the state was on a map made by DeL'Isle in 1701. Voyageurs, thought to be the first Europeans to enter South Dakota, followed this trail to Sioux Falls. More than 100 years later, Joseph Nicollet, travelling along the James River in 1839, reported a trail worn deeply by the Sioux Indians dragging lodge poles. The following year, Rev. Stephen R. Riggs and Alexander Huggins traveled an Indian trail up the Lac Qui Parle River in Minnesota to Two Woods Lake at present Altamont in Deuel County.

Euro-Americans establishing settlements in the American West after the mid-point of the 19th century were not initially attracted to the Dakota plains, and permanent roads were not needed to move supplies and soldiers westward through the Dakotas because the Missouri River facilitated transportation better than overland methods of the time. 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 travelling between the Pierre area and the headwaters of the Platte River. The following year, a company of soldiers travelling from Fort Ridgely 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."

In 1857, Minnesota entrepreneurs, aspiring to establish St. Paul as an eastern railroad terminus of a Pacific railroad, obtained a Congressional appropriation to construct an emigrant road from that city to the Oregon Trail at South Pass in the Rocky Mountains via Fort Ridgely 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 utilizing 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 Elkpoint, Vermillion, and Yankton. As it established other military posts, the Army connected them with a rudimentary network of roads. In 1865, the U.S. 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 saw mill to produce lumber for bridges at Sioux City, Vermillion, and the James River.

Given a sense of security by the presence of military forts, settlers were soon to follow the Army into the Territory, but river crossings presented a major problem as they began to lay out roads. Many roads were laid out to take advantage of fords or crossings which were already in use. As roads were improved, these same crossings often became the location for bridges in later years. For example, Ben Ash established the Bismarck Crossing of the Belle Fourche River in Butte County in 1875 to serve a wagon road between Bismarck (the rail head of the Northern Pacific Railroad) and the Black Hills. Bismarck businessmen seeking access to the markets created by the miners in the Black Hills provided financial backing to Ash for building the road. The Bismarck Bridge[bridge no. 10-395-403] was constructed at this crossing in 1912. Where fords were not feasible at the larger rivers, the counties licensed toll ferries that operated a few months of the year. Except for a few military structures, however, few bridges were built in South Dakota until statehood in 1889.

Eventually, the settlers and their local governments did build bridges. Structures built during the 1870s-1880s were relatively short of span and temporary in nature. Local carpenters usually built small bridges that were rather crude affairs, typically consisting of an unsophisticated superstructure supported by an unsound substructure. Minnehaha and Hutchinson counties provide good examples of bridge-building practices during the early years of settlement in southeastern South Dakota. In 1871, the voters in Minnehaha County approved a tax of one mill for roads and bridges, and increased the tax to two mills for roads and one mill for bridges by 1878. The Commissioners Record for the period lists numerous requests from county road districts for bridge materials, usually in amounts under $50 paid to individuals. Similarly, the Commissioners Record for Hutchinson County during the 1880s lists payments from the bridge fund for lumber, bolts, nails and labor. Rarely did these small bridges last more than a few years, either collapsing under a heavy load or washing away in spring floods. In 1881, the Minnehaha Commissioners 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 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 built in 1876 by R.F. Pettigrew, the Tenth Street Bridge over the Big Sioux River in Sioux Falls constructed in 1878 by Lynch and Desparois of Sioux

City, and a bridge over the Big Sioux River at Dell Rapids constructed in 1879 by the DuBuque Bridge Company. These proved not to be very substantial bridges so in 1882, the county rebuilt the Eighth and Tenth Street Bridges in Sioux Falls. The sporadic bridge building activity of the 1870s became more rationalized 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 attracting markets from the west. Hutchinson County did not begin its major bridge construction projects until the late 1890s.

RAILROAD ERA

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 and 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.

Not until the economic depression of the 1870s came to an end did South Dakota attract the interest of major railroads. The Chicago and North Western, with the vision of promoting settlement on the South Dakota prairies, and the rival Chicago, Milwaukee, and 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 and North Western at Pierre and the Chicago, Milwaukee and 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 functioning smoothly. This relationship between railroads and vehicular roads continued into the 20th century as railroad companies supported the "Good Roads" movement, believing it would bring more traffic to their stations and freight yards.

Although railroads built numerous bridges in South Dakota, almost all are beyond the scope of this project, which deals only with spans which carry, or cross, public roads. Incidently, the oldest known bridge in South Dakota is a railroad bridge built over the Big Sioux River near Brandon for the Chicago, Minneapolis, St. Paul and Omaha (since absorbed by the Chicago and Northwestern) by the Lassig Bridge and Iron Works of Chicago in 1889. Nevertheless, railroads had a significant influence on the evolution of vehicular 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 further aided the establishment of reliable bridges by bringing the iron and steel from suppliers and fabricators in industrial states to South Dakota for bridge construction.

The decline of the railroads began just after World War I. The popularity and availability of motor vehicles resulted in diminishing local rail passenger and freight business in the 1920s. In the following decades, railways cut services and dismantled tracks. Through the rest of the twentieth century increasingly effective competition continued to cause railroad abandonment, while technological changes enabled companies to carry the remaining traffic with fewer tracks and facilities. The legacy of railroads is still apparent, however, in the locations of towns and the configuration of facilities such as grain elevators serving economic activities of the state. Thus, many roads and bridges are part of this railroad legacy as components of the infrastructure devised largely for transporting grain to rail shipping points.

THE IRON AND STEEL 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 19th century engineers developed trusses which 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 diagonal members in tension; and the Warren truss (developed in the United States by Squire Whipple in 1849 without knowledge of James Warren's invention of the same truss in England the year before), which had diagonals in both tension and compression. In the mid-19th century, the Howe truss was the most commonly used wood truss; by the late 19th century, when iron and steel replaced wood for longer spans, the Pratt became the most widely used truss. In the 20th 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 widely 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 the unusual 1894 hybrid of the Pratt and Warren configurations built in Hamlin County (Bridge No. 29-221-060) by the King Bridge Co. The only other example known to exist spans the Yellow Bank River in Lac Qui Parle County, Minnesota. It was built by the King Bridge Company in 1893.

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 at by the close of the 1870s their use largely ended. Although bowstring arch bridges are extant in Minnesota, Nebraska, and Wyoming, none are known to survive in South Dakota.

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."

The oldest known surviving vehicular bridges in South Dakota are the Hall Bridge in Spink County (bridge no. 58-108-196) and the Mud Creek Bridge (no. 07-290-371) near Groton in Brown County. The superstructure of the Hall Bridge was originally built in 1893 over the James River, but has since been moved to its present location north of Redfield. Built by the Wrought Iron Bridge Company, the specifications for the superstructure called for wrought iron. The Mud Creek Bridge may also be of wrought iron, but early records do not specify.

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 virtually disappeared from bridge work in the mid-1890s and by 1894, virtually all bridges in the United States were being built of steel. Thus, other than the Hall Bridge and the Mud Creek Bridge, all of South Dakota's surviving metal truss bridges are almost certainly steel.

Suppliers 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, Lackawana, Bethlehem, and Scullin. South Dakota bridges often include steel from two or more mills. The 1912 Sand Creek Bridge (Bridge No. 56-090-096) north of Woonsocket in Sanborn County has structural components from Carnegie, Cambria, Jones & Laughlin, and Illinois Steel.

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 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 fabricators, 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. Of these firms, only Gillette-Herzog (bridge nos. 07-223-320, 1898; 07-173-440, 1901; and 51-110-195, ca. 1901), the King Bridge Company (bridge nos. 29-221-060, 1894; and 14-088-170, 1898), Western Bridge Company (bridge no. 03-330-115), and the Wrought Iron Bridge Company (bridge no. 58-108-196) have known bridges surviving in South Dakota.

All four of these companies were important regional or national bridge builders. The King Iron Bridge Company and the Wrought Iron Bridge Company were Ohio-based firms, the founders of which held early iron bridge patents. After working as a building contractor and an agent for the Moseley Bridge Company in Cincinnati, Zenas King moved to Cleveland in about 1860 to establish a bridge and boiler works. He received patents on designs for a tubular (bowstring) arch bridge and for a swing-span bridge in the early 1860s. Like King, David Hammond began his building career as a carpenter. One of the principals in the Wrought Iron Bridge Company, Hammond also received several patents in the early 1860s for varieties of bowstring arch truss designs. By the mid-1870s, the Wrought

Iron Bridge Company had already built several iron bridges west of the Mississippi in Minnesota, Iowa, Nebraska, and Kansas, as well as throughout the rest of the nation. Both the King and Wrought Iron companies developed extensive networks of agents west of the Mississippi River to bid on county bridge work. One of those agents, George E. King, a nephew of Zenas, worked west of the Mississippi for his uncle for several years before forming his own bridge-building company at Des Moines in the late 1880s.

The Gillette-Herzog Manufacturing Company and the Western Bridge Company grew out of earlier, smaller operations. Gillette-Herzog had its origins in the Northwestern Fence Works, a small Minneapolis-based wrought iron fabricator dating to the 1870s and owned by Philip Herzog. In the mid-1880s, the firm expanded to produce iron work for banks, prisons, and jails, and hired a civil engineer named Lewis S. Gillette, who had worked for James J. Hill's St. Paul, Minneapolis and Manitoba Railroad and for the St. Anthony Falls Water Power Company. By the late 1880s, Gillette was president of the company, his brother George was secretary-treasurer, and a new bridge department was established with Alexander Y. Bayne as manager. The company also reorganized as the Gillette-Herzog Manufacturing Company. Bayne, who had operated his own Minneapolis-based bridge-building company in the late 1880s and had been active in the Dakotas, quickly established Gillette-Herzog as one of the active bidders for South Dakota bridge projects. The Western Bridge Company, a fabricating and construction company based in Chicago, was started about 1898 with H.S. Wetherell as President. Prior to that, Wetherell had operated his own bridge-building firm and had built some bridges in South Dakota. The Western Bridge Company conducted its South Dakota operations out its branch office at Council Bluffs, Iowa.

19th Century Bridge Designers and Their 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 specification 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 descriptive name for the truss type means that all of the members of the truss are connected with large pins rather than being riveted. The meaning of the designation as a Pratt truss has already been described earlier in this section. The 1897 bridge near Forestburg (Bridge No. 56-117-123) in Sanborn County is rare because it is a pin-connected Warren through truss. As mentioned earlier, Warren trusses were not widely used until the riveted connection became commonly used in the early 20th century.

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. The Hall Bridge (no. 58-108-196) is a pin-connected Pratt through truss. Although generally used for spans of more than 100 feet, some through trusses with spans as short as 70 feet survive in South Dakota (like the bridges built for the U.S. Reclamation Service over the Belle Fourche diversion canal, bridge nos. 10-109-360, 10-112-355, 10-135-348, and 10-148-351).

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 (no. 24-162-102) built in 1929 over the Burlington Northern's tracks in Fall River County, and Cheyenne River Bridge near Wasta (bridge no. 52-824-300), 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 the 19th century. The Mud Creek Bridge (no. 07-290-371) is the only surviving pony truss bridge built for vehicular use known to survive (a pin-connected Warren pony truss in Jackson County, no. 36-365-330, was originally built as a railroad bridge).

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. His only known surviving bridge is located across Mud Creek in Brown County (bridge no. 07-290-371). Bullen built this 40-foot, pin-connected Pratt pony truss in 1893 for $476. 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. Stark's two known surviving turn-of-the-century bridges are the 100-foot pin-connected Warren through truss (bridge no. 56-117-123) built in 1897 over the James River near Forestburg in Sanborn County and the 70-foot pin-connected Pratt pony truss (bridge no. 06-131-040) built in 1900 over the Big Sioux River near Bruce in Brookings County. During the 1910s, Stark's company would specialize in reinforced concrete bridges.

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.

National Register of Historic Places
Continuation Sheet

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 bidders 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 19th century contractors of steel or iron bridges had generally, but not always, been fabricators as well, in early 20th 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 firms 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. At the time of the South Dakota Historic Bridge Survey, Bayne's oldest surviving bridge in the state was a 70-foot riveted Warren pony truss (bridge no. 07-103-440) built in 1905, but now recently demolished at its crossing of Moccasin Creek near Warner in Brown County; his surviving bridge with the longest span is a 75-foot pin-connected Pratt pony truss (bridge no. 07-003-400) built in 1910 over Snake Creek near Aberdeen.

William S. Hewett is another Minneapolis-based contractor who was active in South Dakota in the early 1900s. 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. His only known surviving South Dakota bridge is a 60-foot pin-connected half-hip Pratt pony truss built in 1902 and now spanning the South Fork of Snake Creek near Zell in Faulk County. 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 (bridge no. 20-153-210) built in 1908 and now spanning an irrigation ditch near Brandt in Deuel County. The longest Security Bridge Company span surviving in South Dakota is an 80-foot pin-connected Pratt through truss (bridge no 25-320-101) built in 1909 over the South Fork of Snake Creek near Cresbard in Faulk County. A longer through truss built by the Security Bridge Company survives in Watertown, but it has lost integrity. Originally built in 1911 as a vehicular bridge, the superstructure has since been moved to the city zoo and has been adapted for use as a monkey cage.

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 (1903-1919), Bon Homme (1902-1917), Brookings (1903-1918), Clay (1905-1910), Douglas (1905-1910), Hamlin (1909-1913), Hand (1909-1914), Hutchinson (1905-1911), Sanborn (1902-1912), Spink (1903-1921), and Turner (1905-1911) counties and winning occasional contracts in Brown, Davison, and Miner counties as well. President of the company was James S. Carpenter, who had been a travelling 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. The oldest surviving Iowa Bridge Company structures in South Dakota were both built in 1903: the Turtle Creek Bridge (bridge no. 58-025-370) is a 60-foot pin-connected Pratt pony truss near Tulare in Spink County; the Big Sioux River Bridge (bridge no. 06-129-020) is a 70-foot pin-connected half-hip Pratt pony truss near Bruce in Brookings County. The two longest spans of the Iowa Bridge Company surviving in South Dakota are both in Spink County. One (bridge no. 58-218-360) is a 140-foot pin-connected Pratt through truss built in 1910 over the James River near Frankfurt; the other (bridge no. 58-140-224) is a 150-foot riveted Parker through truss built in 1919 over the James River near Redfield.

The other Des Moines bridge-building firm which was especially active in South Dakota early in the 20th century was the Federal Bridge Company, but it did not organize until the second decade of the century. 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 South Dakota in 1911, the Federal Bridge Company was successful in earning annual bridge contracts in such counties as Clay, 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. Several Federal Bridge Company bridges in South Dakota are known to date from 1912, the longest of which is the Russell-Dawson Bridge (bridge no. 14-108-213), a 150-foot riveted Warren through truss built over the Vermillion River on the south side of Vermillion.

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 in that city 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. The only known surviving example in South Dakota of the Standard Bridge Company's standardized trusses is a 60-foot riveted Pratt pony truss (bridge no. 62-220-512) built about 1914 over the Keya Paha River near Wewela in Tripp County. Two South Dakota bridges survive to represent the Standard Bridge Company's development of various steel girder structures, of which the transverse joist bridge was one type. The bridge over the East Fork of the Vermillion River (bridge no. 44-212-090) near Montrose in

McCook County is a transverse joist structure built by the Standard Bridge Company in 1914. The bridge over an unnamed creek near Dallas on the line between Tripp and Gregory counties is a through steel girder structure with transverse floor beams built by the Standard Bridge Company in about 1920.

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. Towle also had interests in several related companies, including the Nebraska Bridge Supply and Lumber Company, Concrete Engineering Company, Omaha Structural Steel Works, and Allied Contractors, Inc. One bridge built by John W. Towle prior to the formation of the Western Bridge and Construction Company is known to survive in South Dakota, the 80-foot pin-connected Pratt through truss (bridge no. 50-190-132) built in 1906 over the Big Sioux River in Mapleton Township, Minnehaha County. (Another Minnehaha County bridge, no. 50-196-104, was probably built in 1903, also by Towle, but evidence is not as definitive as for no. 50-190-132.) The oldest surviving structure of the Western Bridge and Construction Company is the 110-foot pin-connected Pratt through truss (bridge no. 50-271-200) built in 1907 over Split Rock Creek in Split Rock Township, Minnehaha County. The longest span for a surviving Western Bridge and Construction Company bridge is the 150-foot pin-connected Parker through truss (bridge no. 50-193-086) built about 1910 over the Big Sioux River in Sverdrup Township, Minnehaha County. A small number of bridges built by Towle's other interests also survive in South Dakota. A 40-foot riveted Warren pony truss (bridge no. 39-079-210) was built by the Omaha Structural Steel Company in 1913 over Redstone Creek near De Smet in Kingsbury County. Allied Contractors, Inc., built the Sixth Avenue Bridge over the Belle Fourche River in Belle Fourche (bridge no. 10-099-210) in 1921.

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. Four of these 70-foot pin-connected Pratt through trusses survive (bridge nos. 10-109-360, 10-112-355, 10-135-348, 10-148-351). That same year, the Butte County Commissioners 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 (bridge no. 10-329-404) survives. The surviving bridge with the longest span built by the Canton Bridge Company is the Bismarck Bridge (no. 10-395-403), a 200-foot pin-connected Pennsylvania through truss built over the Belle Fourche River in 1912.

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 formation of the Pioneer Bridge Company are known to survive. Several Pioneer Bridge Company structures do, however, the oldest of which is the 50-foot riveted Warren pony truss (bridge no. 18-060-202) built in 1912 over Twelve Mile Creek near Mitchell in Davison County.

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. Two bridges built by

J.A. Crane and Sonsare known to survive, both in Turner County: the 70-foot pin-connected Pratt through truss near Davis (bridge no. 63-224-190) that was built in 1903 over the East Fork of the Vermillion River; the 105-foot pin-connected Pratt through truss near Parker (bridge no. 63-160-056) that was built over the same stream in 1905.

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 become Gales Township, Aurora County, in 1882. Mike Gales was elected county commissioner in 1895 and county treasurer in 1898. Beside 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 bidding against the Canton Bridge Company and the Pioneer Bridge Company. Gales continued to receive annual contracts in his home county through the end of the decade. Gales' only known surviving bridge is a 36-foot riveted Warren pony truss (bridge no. 02-030-271) built in 1916 over Platte Creek south of White Lake.

Other South Dakotans in related businesses 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 earlier rejected all 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. At the time of this survey, two of Gilbert's bridges survive, both 60-foot Pratt pony trusses. The one over Mud Creek near Stratford (bridge no. 07-211-460) was pin-connected, but has since been destroyed. The only known surviving bridge built by Gilbert crosses the James River near Hecla (bridge no. 07-268-030), is riveted, and has been moved from its original location over Mud Creek. 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 & Northwestern Railroad, several other individuals, in succession, did attempt 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. One bridge built by this company survives, a 75-foot riveted Pratt pony truss (bridge no. 07-042-110) built in 1913 over the James River west of Houghton, but since moved to the Elm River near Frederick. 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. (Kiernan apparently retired from the contracting business to become the postmaster of Whitewater.) 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. In 1916, Brown County adopted the bridge plans submitted by the Whitewater Bridge Company, subject to approval by the State Engineer, but the plans were rejected. Nevertheless, the Whitewater Bridge Company was successful in winning the annual bridge contract for 1917, plus a special contract to build a bridge at Tacoma Park. The latter, an 80-foot riveted Warren pony truss (07-231-276), still spans the James River 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 which distinguished some 20th century bridge builders from their predecessors, 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. The only surviving bridge (bridge no. 07-220-454) built by the Aberdeen Construction Co. is a standard South Dakota State Highway Commission pony truss design with concrete approach guards.

HISTORY OF STONE-ARCH BRIDGES

Although fairly common in some parts of the United States, stone-arch bridges were apparently 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. Deuel County has the only known surviving stone-arch bridge built prior to the 1930s, and the county is known to have built others. The surviving stone-arch bridge in Deuel County is the Old Cochrane Road Bridge (no DOT no.). It has a single six-foot span and was probably built between 1900 and 1910. 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.

HISTORY OF 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 some 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 systemsoon 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 (bridge no. 68-128-204, destroyed in 1989), which is the oldest surviving reinforced concrete bridge in South Dakota, the City of Yankton went on to build two similar concrete-arch bridges (bridge nos. 68-122-204 and 68-124-204) 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 (bridge no. 39-006-070), built by R.S. Warner in 1911; the Eighth Street Bridge in Sioux Falls (bridge no. 50-203-206), a three-span arch bridge built by N.M. Stark in 1912; and the two Riverside Township bridges in Moody County (bridge nos. 51-102-010 and 51-106-010) built by Ward and Weighton in 1915. All of these bridges have 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 neo-classical treatments given railings of eastern bridges. The Minnesola Bridge (no. 10-114-395) near Belle Fourche in Butte County has been documented as a Concrete Engineering Company structure. Documentation for two similar structures, the Spring Creek Bridge (no. 47-151-389) near Sturgis in Meade County and the Rapid Creek Bridge (no. 52-575-383) near Farmingdale in Pennington County, were not found in county records, but the character of their guardrails, like that of the Minnesola Bridge, derives from 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 and Pacific Railroad to create grade separations where country roads intersected its tracks. These, such as bridge no. 55-030-418 in Roberts County, were built in 1912, and carry railroad tracks over vehicular roads. The Milwaukee Road bridges over rural 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). The oldest surviving concrete slab bridge in South Dakota is the De Smet Township Bridge (no. 39-176-100) near De Smet, a two span structure built by Carl H. Schultz of De Smet in 1914. He was among the first contractors in the county to build concrete bridges. The longest concrete slab bridge in the state, at 27 feet, is the Rock Creek Bridge (no. 49-095-190) near Howard in Miner County. It was built in 1917 by either the Pioneer Bridge Company or Lindbloom and Gustavson.

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. The earliest such structure is the Enemy Creek Bridge (no. 18-142-150) near Mitchell in Davison County. Consisting of a single 30-foot span, it was built by the Pioneer Bridge Company in 1915. Another early concrete girder bridge is the Wolf Creek Bridge (no. 44-028-220) near Bridgewater in McCook County. A single 40-foot span, it was built by the W.A. Barnhart Construction Company of Salem according to plans supplied the County by the Dakota Engineering Company of Mitchell. These early bridges have guardrails consisting of solid concrete parapets with recessed panels, a typical feature of early state-designed concrete bridges. A unique bridge in South Dakota has this feature, but the parapets are much thicker than usual and are actually the concrete girders that span between abutments. Known as the Larson Bridge (no. 15-239-160, see Fig. 11), this Codington County structure has cast-in-place, reinforced-concrete, transverse floor beams, attached along the lower edge of the through girders, to support the concrete deck. It was built in 1917 by the Marshall (Minnesota) Tile and Sidewalk Company.

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 thegeneral 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 beams, and the steel 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 beams and floor slab, the bridge railing, and finally the vertical hangers. Three Rainbow Arches survive in South Dakota, the oldest of which is at Miller (bridge no. 30-154-258). The Iowa Bridge Company built the 40-foot span for Hand County over Ree Creek in 1914. The other two date from 1917: the Third Street Bridge (no. 58-090-251, historically known as the Hugo Street Bridge) was built over Turtle Creek in Redfield, also by the Iowa Bridge Company; the Capitol Street Bridge (no. 68-124-203) over Marne Creek in Yankton was built by the local Ellerman and McLain Company. Rainbow Arch bridges cost more than steel-truss bridges of like span, but because they were located at major crossings in cities, local governments were willing to accept the extra cost because of the aesthetic dimension the arches offered. In the case of the bridge at Redfield, the state engineer balked at the cost of the bridge until he was informed that it was a Rainbow Arch.

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 (nos. 51-102-010 and 51-106-010) 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 some 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 some Codington County concrete bridges, including a reinforced concrete slab bridge south of Rau (bridge no. 15-210-136). 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 some 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 identified by RTI as awarding 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 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 letting 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 which 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.

Proposals for three bridges to be built in Spink County found in the "Bridge Contracts" files suggest that pooling was practiced early in South Dakota. Five of the proposals indicate that the location where the contractors prepared their bids was Frankfort, Dakota Territory (a small town a short distance from Redfield, the county seat), and all seven carry the date of July 14, 1886. Two hundred dollars separated the bids of the five out-of-state bridge building companies for the $5000 bridge.

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 1904without 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.

County commissioners sometimes communicated with their counterparts in neighboring counties to compare bridge-building costs. In Spink County in 1909, a roll call vote was called for by one of the commissioners on the vote to renew the county's annual contract with the Iowa Bridge Company; he cast the only negative vote. Prior to renewal of the contract in 1910, however, a committee was appointed to investigate bridge construction in other counties. The committee found the costs to be similar and that it was more practical to let bridge work on an annual basis. The findings evidently did not satisfy the lone dissenting commissioner, for after spending a full day in discussing the 1910 contract, he again cast a negative vote.

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. By 1903, the Minneapolis Steel and Machinery plant in south Minneapolis covered about two and one-half blocks. 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 it's county crews. One of the bridges Hand County built using Minneapolis Steel and Machinery steel during this period is the 1916 bridge over Sand Creek (bridge no. 30-257-400) near Miller.

THE ERA OF STATE CONTROL OF BRIDGE BUILDING

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 publicfunds 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 move 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.

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 consitutional 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 consitutional 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 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 an 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 hinderance." 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 work load 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. "[B]y 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 (bridge no. 07-304-414). 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 (bridge no. 03-020-008).

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 "pracitically 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 (bridge no. 25-218-141) 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 found during research for this project 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 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 was replaced every five or six years. Kirkham also claimed that the floor distributed the load more uniformly over the structure. The February 1923 <u>Engineering News-Record</u> carried an article on "tar wood floor" in which it was compared to a similar flooring used on some of Chicago'sviaducts. 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 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 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 hisbelief 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. Numerous of these standardized SHC pony trusses with vertical end posts and concrete approach guards survive on the South Dakota landscape.

Among the oldest surviving SHC riveted pony trusses of Kirkham's design are the 65-foot bridge (bridge no. 58-010-376) built over Wolf Creek by the Iowa Bridge Company in 1920, the 65-foot bridge (no. 58-021-400) built over Turtle Creek by the Iowa Bridge Company in 1921 (both structures near Tulare in Spink County), and the 50-foot bridge (no. 25-220-454) built over Mud Creek near Stratford in Brown County by the Aberdeen Construction Company in 1921. This design for pony trusses appears to be distinct to South Dakota. Despite Kirkham's belief that is was a superior design, it was not adopted by other states.

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 RiverCounty 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 Department'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 farmers 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 and 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 which changed with the seasons. During summer months licensed entrepreneurs operated ferries. As cold weather approached, the ferries had 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 time 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 come 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 (bridge no. 68-122-210) 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 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 Bismark and Mandan, North Dakota in 1920-22 at a cost $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 58percent 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 intelligent 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. Steel was fabricated by the American Bridge Company.

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.

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 [bridge no. 08-068-084] at Chamberlain in 1953.

The State Highway Commission After the Missouri River Bridges

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 were 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 establish 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, and 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 (no. 52-311-454) 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 tunnels cost much more than standard highway construction at the time, 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 (no. 17-285-196) 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.

New Deal 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, the 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 requirement that the sponsor provide the materials to match the federally financed labor. The intent, of course, was to put as many men to workas 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 [bridge nos. 07-267-330 and 07-091-330] on U.S. 12 crossing the Chicago, Milwaukee, St. Paul and 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 some very finely designed and crafted bridges. One of the most picturesque is the multi-plate-arch bridge [no. 15-181-171] 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 for railings so there would be no obstacles to hamper snow removal. 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 (no DOT bridge no.) 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 (no. 50-315-085) 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 the Big Sioux River south of Dell Rapids is a former railroad bridge, typical of those built by the Chicago, Minneapolis and 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 (bridge no. 17-596-138) at Ellsworth Air Force Base near Rapid City.

F. Associated Property Types

I-A. Name of Property Type: Iron and Steel Frame Bridges

II-A. Description

Iron and steel bridges within this property type each consist of a framework superstructure which supports the roadway over the span of the bridge. The framework consists of individual members which form a prominent geometric pattern of solids and voids. Each individual member consists of iron or steel shapes of various sizes, such as angle sections, channel sections, I-beams, and round and square rods. Some composite or built-up members consist of multiple shapes attached to each other by means of rivets and lacing bars, lattice bars, or batten plates. Wrought iron was the preferred material for these members prior to 1890. There was a brief transitional period in the early 1890s, after which steel became the material of choice for bridge designers. Despite the metallurgical difference between wrought iron and steel, bridge fabricators used the two materials similarly in producing various members and the framework configurations for bridge superstructures remained virtually identical.

There are other kinds of iron and steel bridges in South Dakota which differ from those included in this property type. Multi-Plate Arch Bridges, which are discussed as a separate property type (see continuation sheet ??), are built of galvanized, corrugated, plates which are bolted together on-site to form a vault similar to a culvert. The Multi-Plate Arch supports earthen fill which in turn supports the roadway. Multi-Plate Arch Bridges, therefore, do not constitute a framework. Likewise, steel stringer and steel girder bridges do not constitute a framework, but rather rely on simple I-beams (steel stringers) or built-up girders to carry the roadway between the supports. Their use is associated with important historical changes in industrial capacity to produce such shapes and in contractors' ability to economically erect bridges using such shapes (see continuation sheet ??)

Bridges in this property type are usually divided into four categories, which characterize their differing framework configurations They are: (1) iron and steel pony truss bridges, (2) iron and steel through truss bridges, (3) iron and steel deck truss bridges, and (4) iron and steel arch bridges. Site conditions usually determined which type of bridge would be used. Pony or through truss bridges were generally selected when there was relatively little difference between the level of the road and the level of the water. Deck truss and arch bridges were used where that elevation difference was great, such as when a bridge was needed to carry a road over a deep gorge. Pony trusses served relatively short spans (usually up to 90 feet), through and deck trusses served longer spans (usually over 100 feet), and arch bridges served very long spans.

Bridges in the first three categories (pony, through, and deck) are distinguished by the position of the roadway, or deck, relative to the pairs of trusses that span between the supports (piers or abutments). In the case of a pony truss bridge, the deck is attached to the lower chord, or bottom edge, of each truss and the trusses are low enough that there is no need for overhead bracing to resist lateral sway. For a through truss bridge, the deck is also attached to the lower chords, but the trusses are high enough that they require overhead bracing to resist lateral sway. In the case of a deck truss bridge, the deck is attached to the upper chord, or top edge, of each truss.

[XX] See continuation sheet

[X] See continuation sheet for additional property types

Bridges in this property type are also be categorized by the configuration of the trusses themselves. In most cases, the name for each truss type comes from the person or company who developed it. The most common truss configurations in the United States are the Howe, Pratt, and Warren. No Howe trusses were found during the South Dakota survey. Howe trusses date from the 19th century and usually used wood for the compression members. South Dakota's Howe truss bridges have long since been replaced by other bridges.

Pratt trusses are characterized by vertical compression members (because they are designed to be in compression, these members are relatively thick and prominent visually) and diagonal tension members (because they need only function in tension, these members are relatively thin). Pratt trusses have horizontal upper chords. There are several other truss types related to the Pratt that have vertical compression members and diagonal tension members. They include the Parker truss, characterized by a polygonal upper chord; the Camelback truss, having exactly five sides to the polygonal upper chord (including the inclined end posts); the Baltimore truss, having a horizontal upper chord and sub-divided panels; the Pennsylvania truss, having a polygonal upper chord and sub-divided panels; and the "bedstead" truss, so named because it has vertical end posts, resembling a bedstead, rather than inclined end posts. Pratt trusses, and those closely related to Pratt trusses, were commonly used until about 1920. After that date, variations of the Pratt were most often used for major river crossings.

The other major type of truss is the Warren, characterized by diagonal members which function in both tension and compression and therefore are relatively thick. The diagonal members form a "W" pattern along the length of the truss. Warren trusses may or may not have vertical members, which are usually thinner than the diagonals. Warrens are usually associated with 20th century bridge construction when they began to supplant the Pratt. Although sub-divided and multiple intersecting Warrens exist, none of the variations of the basic Warren truss were identified in the South Dakota survey (with the exception of one lattice through truss span in Minnehaha County [bridge no. 50-200-035], which was originally built for a railroad).

Three other types of steel frame bridges were identified in South Dakota: 1) The Castlewood Bridge [bridge no. 29-221-060] in Hamlin County is an unusual hybrid of the Pratt and Warren configurations; 2) three lattice truss bridges made up of lattice bars connecting the upper and lower chords serve relative short spans in Aurora and Butte counties (They would have been riveted and shipped in one piece from the factory.); 3) nine kingpost pony trusses represent a basic type that forms a simple triangle. Although kingpost trusses date to ancient times, and were usually built in wood during the 19th century, a few were constructed in metal during the 20th century, spanning lengths from 30 to 40 feet in South Dakota.

There is another important distinction to make between various truss bridges, and that is the type of connection used at the points where members intersect. During the 19th century, most iron and steel truss bridges were pin-connected, meaning that at each intersection of vertical, diagonal, and chord members, they were held together by a pin set through holes in the members. Around the turn of the century, bridge designers and builders began to make greater use of riveted connections, especially for short-span bridges. This meant that at their intersections, the vertical, diagonal, and chord members were riveted to a steel gusset plate rather than being pin-connected. By the 1920s, the riveted connection replaced pins for many longer spans as well.

Trusses of the same type (for example, the pin-connected Pratt through truss) exhibit subtle differences in certain details, such as nameplate patterns, portal bracing, composition of built-up struts and chord members, and floor beam connections. Other than the name plates, which are obvious because of their verbal nature, it is not generally possible to draw a direct correlation between these various characteristics and the different builders or fabricators.

Bridges in this property type built after 1919 tend to exhibit the standardized characteristics which resulted from establishment of the State Highway Commission's plans and specifications. The SHC mandated that these plans and specifications be used by the counties at most sites. Obvious exceptions to the standardized characteristics were the larger bridges which had to be designed to meet the exigencies of their particular sites. Designs for these bridges, however, were provided by the SHC engineers.

Although the superstructure is the most significant aspect of bridges in this property type, the substructure is also important. Nationally, the earliest bridges in this property type were built with stone abutments and stone piers. In South Dakota, during the 19th century, the most common substructure for through trusses consisted of paired, concrete-filled tubular piers consisting of riveted iron or steel plate. These served as piers under the main span(s) and were typically accompanied by short, timber stringer approach spans. Abutments in these cases were usually timber piles with plank back walls. Pony trusses most often were built on timber piles with plank back walls. Around 1910 steel piles with plank backwalls became common although concrete was preferred by some counties. Some bridges from the 19th and early 20th centuries retain their historic substructure, while others have been replaced.

Bridges in this property type are most commonly found in the rural areas.

III-A. Significance

The governing historical context for this property type examines South Dakota highway bridge construction for the period ending in 1942. Since the context applies to some structures that are not yet 50 years old, it is necessary to consider the issue of "exceptional significance." According to the research and field survey findings of this study, there is only one bridge in this property type that needs to be evaluated using the National Register of Historic Place's guidelines for considering properties that have achieved significance with the last fifty years. Spans of the Chamberlain and Wheeler Missouri River bridges were moved and combined in 1953 [bridge no. 08-068-084]. All remaining bridges can be evaluated under the National Register Criteria A, B, and C. Since research and field survey were conducted on a statewide level and in local county commissioners records, there is a sound basis for making judgments of statewide as well as local significance. Additional research at the local level may establish significance for some additional bridges.

Because virtually every bridge in South Dakota is associated with the "broad pattern" of transportation, one could use Criterion A liberally to find every bridge in the state that retains integrity eligible for the National Register. This, however, would make the process meaningless. Rather, to be eligible under Criterion A, a bridge must have contributed in a meaningful way to the settlement and development of a geographically definable area, facilitated major passage to or through a region, or played a significant role in the development of an effective transportation system. Consequently large bridges over major rivers are most likely to have significance for their historical associations to regional development or settlement. Smaller bridges may be historically significant for association with the development of an effective local transportation system. Examples would include bridges which were built as a result of an important railroad/street grade separation program.

In evaluating a bridge's significance under Criterion A, it is helpful to consult other historical contexts dealing with the general geographical area, especially those prepared for municipal and county surveys. Generally speaking, a bridge is significant for its historical associations with a region only if it dates from the period of significance established for that region. For example, the second bridge over a major waterway may not be significant for its historical associations if the region's major period of development occurred prior to construction of the bridge.

Bridges are rarely eligible under Criterion B. When a bridge is associated with a significant individual, it is almost always an engineer, contractor, or fabricator. According to the National Register's guidelines, such cases are to be treated under Criterion C. It is conceivable, however, that a bridge might have played a pivotal role in the career of an important politician or other civic leader who, perhaps, advocated its construction or preservation. In such a case, the structure might be eligible under Criterion B.

Criterion C is most frequently invoked for finding historic bridges eligible for the National Register. As in the case of Criterion A, an overly liberal application might lead to the determination that all bridges are eligible, particularly as "representatives of a type." Rather, Criterion C should be employed to winnow a group of similar resources to a meaningful list. Instead of looking simply to typicality as an indicator of significance, evaluation under this criterion should identify additional important qualities, such as being the sole surviving example, the oldest example, the longest span, the most intact example, the work of a major engineer, fabricator, or contractor, or exhibiting notable engineering or decorative details. By selecting the superlative examples from the major structural categories, a list of truly important bridges can be gleaned from a large number of similar resources.

The bridges in this property type are built of either iron or steel. While it requires a metallurgical analysis to ascertain conclusively whether a bridge is iron or steel (or is comprised of both iron and steel members), date of construction can be a fairly reliable guide. Both cast and wrought iron had been used for bridge construction around the middle of the 19th century, but the failure of the Ashtabula Bridge (Ohio) in 1876 confirmed engineers' suspicions that the brittle nature of cast iron made it unreliable for bridges, even when used for compression members. Wrought iron was well-suited for applications in both compression and tension, and became the standard material for most bridge trusses in the 1870s and 1880s. Even though the Eads Bridge in St. Louis was successfully built of steel in 1874, engineers were reluctant to use the new material because they were still unfamiliar with its properties and questioned how reliably it could be manufactured. By 1890, however, bridge engineers had allayed their doubts and began using steel for bridges extensively; by 1894 steel was used almost exclusively. In South Dakota, the two surviving truss bridges which pre-date 1894 may be either iron or steel. Truss bridges built between the advent of steel as the typical truss bridge material and 1900 are significant as the earliest examples of steel truss bridges in South Dakota.

There are several truss types represented in South Dakota's inventory of surviving historic bridges. The most common among 19th- and early-20th-century bridges is the Pratt truss (usually pin-connected); this type is therefore important to South Dakota because of its early ubiquity. Representatives of this type may be selected for other associations such as length, age, material of construction, or association with an important engineer, fabricator, or contractor. Another common truss type from the early 20th century is the Warren (usually riveted); significant representatives may again be identified through other associations. Some types of historic iron and steel bridges are quite rare and are quite important in the evolution of bridge engineering. Other truss types are significant examples of the continuing efforts on the part of engineers to devise new configurations which would make truss bridge construction more safe, economical, or durable.

Some truss bridges may be significant because they embody characteristics not typical of standard applications. These may include special decorative features or elements of engineering design which allowed the bridge to meet unusual site conditions. Most truss bridges were unadorned, other than some minor elaboration of the portal bracing or a maker's plate or nameplate listing local government officials. In a small number of cases, however, clients were willing pay a little extra for non-functional decoration, such as finials at the tops of the inclined end posts, cut-out knee braces for the portal or sway bracing, or cresting along the tops of the portal bracing.

While the superstructure of a truss bridge is usually its most significant feature, the approaches and substructure may also be significant as examples of an earlier workmanship and use of materials or of an obsolete engineering or construction practice. For example, reinforced concrete has nearly always been used for the piers and abutments of truss bridges since the 1920s. Prior to that time, however, a variety of other materials and techniques were used. The most common substructure for through trusses consisted of concrete-filled, tubular piers fabricated out of riveted iron or steel plate. Typically, each end of a truss span would be supported by a pier consisting of a pair of these caissons. Short approach spans would link the main span(s) to the stone or timber abutments. Pony trusses most often were built on timber piles with plank back walls. Around 1910 steel piles with plank backwalls became common although concrete backwalls were preferred by some counties.

Several fabricators and contractors are important to the early history of South Dakota bridge building; therefore, bridges associated with them have historical significance. The Wrought Iron Bridge Company of Canton, Ohio; the King Bridge Company of Cleveland, Ohio; the Western Bridge Company of Chicago; and the Gillette-Herzog Manufacturing Company of Minneapolis, were out-of-state fabricators important for introducing iron and steel bridge technologies to South Dakota. In many cases, these companies were also the contractors for erecting bridges in the state. J.G. Bullen of Ashton is the only documented South Dakota builder of iron and steel bridges during the 19th century. After 1900, Fred Bjodstrup of Mitchell (later the Pioneer Bridge Company) and J.A. Crane and Sons of Centerville established successful in-state bridge building businesses. A few other South Dakotans built small numbers of steel bridges.

IV-A. Registration Requirements

For a bridge in this property type to be eligible for the National Register, the superstructure itself must be substantially in its original condition, including the connections and the composition and configuration of individual composite members. Because the superstructure is the most important feature of bridges in this property type, neither an original substructure nor an original deck and guardrail system are necessary for the bridge to be eligible (although these original components may add to the significance of the bridge). On the other hand, for a bridge in this property type to be eligible, replacement substructure or deck components must be of such scale and composition that they do not overwhelm or otherwise detract from a clear visual impression of the iron or steel frame of the superstructure and its function. Bridges which are eligible under Criterion A or B must have integrity of location. Bridges eligible under Criterion C may have been moved, but they should retain integrity of setting, i.e. they should still span a channel or body of water, railroad tracks, or some other barrier to vehicular travel.

Iron or steel frame bridges in South Dakota may be eligible for the National Register under Criterion A for their association with events that have made a significant contribution to the broad patterns of American history, South Dakota history, or local history, especially in relation to transportation or regional settlement or development.

A bridge in this property type may be eligible for the National Register under Criterion B for its association with an important individual, if that individual was not the designer or builder of the bridge.

Most eligible bridges in this property type will fall under Criterion C. They may be eligible for their association with important structural metal fabricators, bridge contractors, or other individuals or firms who made significant contributions to the design and construction of bridges or transportation systems. Bridges of this type may also be eligible because they embody distinctive characteristics of bridge engineering and construction or significant phases in the evolution of bridge engineering and construction. Under Criterion C, a bridge may be eligible if it was or is:

1. Built Prior to 1895. Such bridges may be constructed of wrought iron and are very rare.

2. Built During the 1890s. Such bridges are probably steel and represent the first extensive use of this material for bridge construction in South Dakota. They are quite rare.

3. Built by a 19th-Century Bridge Fabricator. Several out-of-state bridge businesses also fabricated iron and steel bridges. Several nationally-significant, out-of-state companies, including the Wrought Iron Bridge Company of Canton, Ohio, the King Bridge Company of Cleveland, the Western Bridge Company of Chicago, and the Gillette-Herzog Manufacturing Company of Minneapolis supplied bridge materials for South Dakota projects. These companies are important for introducing iron and steel bridge technologies to South Dakota.

4. A Pony Truss Bridge Which Is not a Kingpost, Pratt, or Riveted Warren Truss. Such bridges are rare and represent important design experiments.

5. A Through Truss Bridge Which Is not a Pin-connected Pratt, (after 1920) Riveted Parker, or (after 1911) riveted Warren Truss. Such bridges are rare and represent important design experiments.

6. A Deck Truss Bridge. Such bridges are very rare and represent a design solution to an unusual site condition.

7. A Bridge With Ornamentation. Such bridges are very rare in South Dakota.

8. A Bridge Which Exhibits Exceptional Engineering Skill to Meet Unusual Site Conditions. Such bridges represent the work of a master.

9. Built by a South Dakota-Based Bridge Builder prior to 1920. This survey identified several individuals (and their companies) in South Dakota who constructed bridges in the State. They are: J.G. Bullen, Fred Bjodstrup (later the Pioneer Bridge Company), J.A. Crane and Sons, Michael Gales, C.E. Gilbert, and W.C. Kiernan and Company. Because of the small number of in-state bridge builders, their bridges are important representations of attempts to compete with established out-of-state bridge building companies.

10. Built by a Bridge Building Company with an Established Period of Annual Contracts in a Particular County. Such bridges are ubiquitous, but representative of important patterns of bridge construction in South Dakota. Representative examples, such as the oldest and/or longest examples of a company or associations with other criteria should be considered. Such bridges are also eligible for listing in the National Register under Criterion A.

11. <u>The Oldest Bridge in a County (prior to 1920)</u>. Bridges with documented dates of construction as the oldest in a county have local significance.

12. <u>The Oldest Bridge of a type in South Dakota</u>. Types of bridges with documented dates of construction as the oldest in a county have state significance.

13. <u>Representative Examples of a Type</u> When bridge types are not represented through other registration requirements, examples of these types based on age, length, multiplicity of spans, and/or documented builders should be selected.

14. <u>Built in 1920 and 1921 and Can Be Shown to Have Been Designed or Built Under the New State Highway Commission Programs and Representative Examples of These Bridges</u>. The riveted bedstead Pratt pony trusses, designed J.E. Kirkham, were the only pony trusses approved by the SHC during the 1920s. They represent the development of a standardized truss design unique to South Dakota. Such bridges represent the efforts of state government to improve the quality of bridge construction in South Dakota and break the hold of the bridge building companies. The earliest and longest examples should be considered.

National Register of Historic Places
Continuation Sheet

I-B. Name of Property Type: Multi Plate Arch Bridge

II-B. Description

Introduced by the Armco Culvert Manufacturer's Association in 1931, Multi Plate is a galvanized, corrugated-iron product that is fabricated in curved segments so that individual pieces can be bolted together in the field to form any part of a complete circle. Multi Plate replaced prefabricated, riveted, corrugated-metal pipe culvert, in use since 1896. Multi Plate's modular nature facilitated field-handling, while permitting the construction of larger spans with thicker gauge. Since individual segments could be shipped in a "nested" position, Multi-Plate also was cheaper to transport than riveted culvert. After World War II, the Multi-Plate arch was largely replaced by the Multi-Plate pipe arch, a backfilled ovoid structure that requires neither abutments nor headwalls.

When a Multi-Plate arch is used in bridge construction, it generally is anchored to concrete abutments with concrete or stone wingwalls at each end. When stone is used for the spandrel walls, the structure takes on the appearance of a stone-arch bridge. Only two multi-plate arch bridges were identified in this survey. Both reflect the New Deal agenda of promoting highway beautification, local craft skills, and labor-intensive public works projects.

III-B. Significance

Compared to the metal truss bridge, the Multi-plate arch bridge enjoyed a very brief period of popularity, confined almost entirely to the decade of the 1930s. During its heyday, however, the Multi-plate arch seems to have provided a viable alternative to reinforced-concrete slab-and-girder construction for short-span bridges. The simpler modular design of Multi-Plate construction made it an ideal choice for the unskilled, work-relief projects of the New Deal era. At the same time, Multi-plate bridge design, by easily assimilating stone headwalls and spandrels, satisfied New Deal priorities for roadside beautification and the encouragement of local craft skills. The significance of the Multi-plate arch bridge, therefore, falls under "Category C." It represents a unique engineering type that frequently incorporated notable aesthetic qualities of local masonry design and workmanship.

IV-B. Registration Requirements

Since the Multi-plate arch bridge is most notable for its modular corrugated-metal construction with concrete or stone headwalls and spandrels, these features should be clearly visible and relatively unaltered. And since the Multi-plate arch bridge enjoyed its vogue at least partly because of the New Deal's encouragement of roadside beautification, the bridge should be on its original site, harmonious with the general setting, of aesthetic quality, and of New Deal vintage.

I-C. Name of Property Type: Steel Stringer and Steel Girder Bridges

II-C. Description

The I-beam in the shape with which we are familiar today (two equal and flat flanges) was first employed in constructing federal buildings in the United States before the Civil War. After the War, the invention of the Bessemer process to produce steel and methods to roll it made the I-beam an increasingly popular building material. It was not until after the turn of the century, however, that I-beams gained acceptance in bridge construction for use in short span applications, supplanting timber stringers. Through the 1920s, standard I-beam sections generally limited the use of steel stringer bridges to 40 feet, but they were seldom seen in spans exceeding 30 feet. For longer spans, steel girder bridges were used. A steel girder is often built up of steel plates and angle sections.

Edward Kirkham, South Dakota's first bridge engineer, developed plans for standardized steel stringer bridges during his first year with the SHC. Kirkham designed steel stringer bridges incorporating both concrete balustrade railings and gas pipe railings set in concrete posts. He also encased the outermost I-beams in concrete to address aesthetic objections to steel stringer bridges.

For lengths over 30 feet, steel girder bridges gradually gained acceptance over traditional truss bridges. Rail transportation problems and limitations of field riveting generally prohibited lengths greater than 100 feet until the 1930s. Steel girder bridges had several advantages over the traditional truss bridges that quickly established their popularity, not the least being less cost in manufacture, erection, and maintenance.

One of the most important uses of steel girder bridges in South Dakota during the 1930s was to create grade crossings separating highway and railroad traffic. Deaths and injuries at these crossings had resulted in a national debate to find solutions to the problem; the railroad companies said that it was beyond their financial ability to construct bridges to separate the traffic. In 1934, the U.S. Congress initiated a New Deal program of highway construction with a high priority assigned to elimination of hazards at railroad crossings. Of the 30 or so constructed, only eight remain. In many cases, these are quite impressive structures on the landscape, rising over long distances to reach the required height from the flat prairie.

III-C. Significance

Although truss bridges attract the greatest attention in any bridge survey because of their visual prominence, the vast majority of bridges in the United States are short span steel stringer and steel girder bridges. The great number and unobtrusive similarity of bridges in this property type make it difficult to identify bridges of special significance. Evolution in design is limited mainly to expanding the length of spans to which they were applied. Nevertheless, their use is associated with important historical changes in industrial capacity to produce such shapes and in contractors' ability to economically erect the bridges. In a few cases, pre-1930 steel stringer and steel girder bridges are clearly eligible under "Criterion A" such as the first bridge (bridge no. 30-257-400) built by county crews in Hand County and the steel stringer with outer concrete girder bridge (bridge no. 25-218-141) designed by the State Highway Commission in 1920. The few remaining grade separation bridges of the 1930s are associated with the unprecedented highway construction programs funded by the New Deal programs.

To establish a representative sample, however, early and/or the longest spans must be used in establishing significance under "Criterion C."

IV-C. Registration Requirements

Since steel stringer and steel girder bridges are usually of a basic design, the bridges should retain complete design integrity. The original railings or balustrades (if any) and substructure should be intact.

I-D. Name of Property Type: Reinforced-Concrete Highway Bridge[1]

II-D. Description

The single Associated Property Type, "Reinforced-Concrete Highway Bridge," includes several related span sub-types: (a) arch spans; (b) slab, beam, and girder spans; and (c) rigid frame spans. In some cases, more than one span sub-types may be found within a single bridge structure. For example, a bridge may have main spans in an arch design and approach spans in a girder design.

All span sub-types in this property type share the common characteristic of employing reinforced concrete to construct a bridge of one or more spans. This property type does not include "plain" or unreinforced concrete bridges; the distinction is academic in South Dakota, however, since no example of an unreinforced-concrete bridge has been located in the state. This property type includes only spans generally designed to be highway bridges.

Reinforcing materials and systems may vary, but usually this situation is found only in arch bridges designed and built before World War I. After about 1921 reinforcing materials and techniques were more or less standardized and did not vary in major ways. Early varieties include the Melan steel-rib design, and related designs by the Standard Reinforced Concrete Company and the Marsh Company.

The reinforced-concrete arch bridge is the most complex span sub-type, in engineering terms, and is the most interesting visually. It was designed and built in South Dakota mainly in lengths between 30 and 50 feet.

Arch bridges may be designed as single-arch spans, multiple single-arch spans, or continuous-arch spans. The fundamental difference is that single spans in any arrangement are independent and can stand alone; continuous spans are dependent upon each other and cannot stand alone.

Most arches are South Dakota are "deck arches," meaning that the arch is below the floor. The only other version of concrete arch bridge in South Dakota is the "through arch," more commonly known as the "rainbow arch" because of its distinctive appearance. It also is sometimes known as the "Marsh rainbow arch," after its original designer and patent-holder, J.B. Marsh and the Marsh Engineering Company.

[1]The description, significance, and registration requirements for this property type are patterned after those developed by Robert M. Frame, III in his Multiple Property Nomination for "Reinforced Concrete Bridges in Minnesota," 1988, on file at the State Historic Preservation Office, Minnesota Historical Society, St. Paul.

The arch element itself may be either a barrel arch or a rib arch. Occasionally a bridge was designed as a double-barrel arch, in which the two barrels may be either adjacent or separate. While reinforced-concrete arches may be either fixed or hinged designs, fixed arches are overwhelmingly the most common in the United States, and the only kind found in South Dakota.

The space between the arch and the floor is the spandrel area. An arch bridge may have either a filled or an open spandrel design. While most barrel arches have filled spandrel areas, and most rib arches have open spandrel areas, any combination is possible. In South Dakota, however, all barrel arches have filled spandrels and all rib arches have open spandrels.

Reinforced-concrete slab, beam, and girder bridges are variations on the same basic design, with the different configurations employed to meet demands of clearance, length, and/or economics. These types were used in some South Dakota counties prior to 1920. but were used extensively after the beginnings of the South Dakota State Highway Commission. The SHC specified them in standard designs as alternatives to wood and metal. After 1920, slabs, beams, and girders were specified almost exclusively for concrete bridges of small to medium spans. The only surviving arch bridge constructed after 1920 was designed for to enhance the aesthetic appearance of its setting in Custer State Park.

The slab span is a square or rectangular panel of reinforced concrete and was recommended for short spans of 10 to 12 feet, with a maximum of 20 feet, prior to World War I. Later the recommended length was extended to 30 feet. Beyond that length, a slab of sufficient strength was not considered to be economical.

For spans at the longer end of the slab range (20 to 35 feet), where the slab would have to be uneconomically thick, the T-beam design was sometimes recommended. The T-beam is a slab constructed with integral concrete floor beams.

For spans beyond the range of the slab, the reinforced-concrete girder was also used. The configuration can be either a deck girder or a through girder. It also can be either a single, continuous, or cantilever design.

The last major span sub-type is the reinforced-concrete rigid-frame span, in which the three sides (floor and two end supports) are rigidly connected at the two "knees," creating a single structure with all elements working together to carry a load. The rigid-frame design was developed in the United States in the early 1920s. Though usually found in a deck version, it could be constructed in a through version. No rigid-frame bridges were identified in South Dakota.

For several of these span sub-types, such as the rigid frame and arches with unusual reinforcing, it may be necessary to consult original plans to determine the exact nature of the design, since the external appearance may be misleading or may not give any clue to the internal construction.

Any of these span sub-types may exhibit a variety of additional functional elements, such as railings, abutments, and piers. In addition, these elements, along with the overall structure, may receive architectural or ornamental treatment. By far the most common architectural style given to bridges is Classical Revival. This is found from the earliest bridges and in bridges from the New Deal era. Occasionally a bridge may exhibit elements of Art Deco or Streamline Deco styling, usually in a mild form and mixed with classical elements.

In many small bridges, particularly slab and girder designs, architectural treatment is found only in the railings. Larger and more urban bridges may have an open-balustrade railing with concrete balusters. Large bridges also may incorporate Classical Revival elements into the design of light standards, piers, abutments, and spandrel walls and columns.

III-D. Significance

The governing historic context for this property type examines South Dakota reinforced-concrete highway bridges for the period 1910 to 1945. Since the context applies to some structures that are not yet 50 years old, it is necessary to consider the issue of "exceptional significance." The topic is discussed more for the sake of completeness than relevance. According to the research and field-survey findings of this study, there is no indication that any bridge falls into this category. It is recommended, therefore, that all bridges be evaluated under the normal National Register Criteria A, B, and C. Since research and field survey were conducted on a statewide level, there is a sound basis for making judgments of statewide significance as well as local significance.

Because virtually every bridge in South Dakota is associated with the "broad pattern" of transportation, one could use Criterion A liberally to find every bridge in the state eligible for the National Register. This, however, would make the process meaningless. Rather, to be eligible under Criterion A, a bridge must have been involved in a meaningful way with the settlement or development of a geographically definable area, facilitated major passage to or through a region, or been significantly integral to the development of an effective transportation system. Consequently, large bridges over major rivers are most likely to have significance for their historical associations with regional development or settlement. Smaller bridges may be historically significant for association with the development of an effective local transportation system. Examples of the latter would include bridges which were built as a result of an important railroad grade separation program.

In evaluating a bridge's significance under Criterion A, it is helpful to consult other historic contexts dealing with the general geographical area, especially those prepared for municipal and county surveys. Generally speaking, a bridge is significant for its historical associations with a region only if it dates from the period of significance established for that region. For example, the second bridge over a major waterway may not be significant for its historical associations if the period of significance determined for that region is previous to the date of the bridge's construction.

Bridges are rarely eligible under Criterion B. When a bridge is associated with a significant individual, it is almost always in relation to an engineer, architect, contractor, or fabricator. According to National Register guidelines, such cases are to be considered under Criterion C. It is conceivable, however, that a bridge might have played a significant role in the career of an important politician or civic leader, for example, who advocated its construction or preservation. In such a case, the bridge might be eligible under Criterion B.

Criterion C is most frequently used in finding historic bridges eligible for the National Register. As in the case of Criterion A, an overly liberal application might lead to the determination that all bridges are eligible, particularly as "representatives of a type." Rather, Criterion C should be employed to winnow a group of similar resources to a meaningful list. Instead of looking simply to typicality as an indicator of significance, evaluation under this criterion should identify additional important qualities, such as being the sole surviving example, the oldest example, the longest span, the most intact example, the work of a South Dakota engineer or builder, the work of an important out-of-state engineer or builder, or exhibiting notable engineering or architectural details. By selecting the superlative examples from the major structural categories, a list of truly important bridges can be gleaned from a large number of similar resources.

The reinforced-concrete highway bridges in South Dakota may be divided int two type includes the following related span sub-types: arch spans and slab, beam, and girder spans. Each span sub-type has one or more variations. Each span sub-type can be found in a design that exhibits one of several architectural styles. Each span sub-type can be found in one of several locational situations that probably influenced both its engineering and its architectural treatments.

There are three eras in the development of the reinforced-concrete bridge in South Dakota: 1) early experimental, non-standardized design, 1910-1919; 2) early South Dakota Highway Commission, standardized design, 1920-1930; 3) established highway department, truck highway, and major urban bridge period, largely affected by New Deal programs, 1930-1945.

The reinforced-concrete arch bridge, in one or another variation, is significant in each era. During the period 1910-1919, before the creation of State Highway Commission standardization, the arch bridge was widely-used. Of particular note for this time would be vernacular designs and local builders.

The concrete slab bridge was the most popular concrete bridge during this period. It first appeared in the more densely populated eastern counties and soon spread across the state. Concrete T-beam and girder bridges are more rare during this period.

The period 1920 to 1930 encompasses the early period of the South Dakota State Highway Commission, when state bridge engineer, John E. Kirkham, developed several standardized slab and girder designs for use in the state.
After the formation of the South Dakota State Highway Commission, arch spans were rarely used.

The first structural indication of a state standard design for a reinforced concrete bridge during this period usually is the railing. Gas pipe rails are set in concrete posts with an "I" shape. The approach guards are flared over, and integral to, the wingwalls and include a recessed panel.

The federal government appears to have had little influence on concrete bridge design and construction through its New Deal programs of the 1930s. In fact, it appears that the state almost exclusively used steel stringer and girder bridges during this period, especially for longer span bridges. Only two concrete bridges constructed under New Deal programs were identified in the South Dakota bridge survey among a half-dozen concrete bridges constructed during the decade.

Subsidiary bridge elements may enhance the overall significance of a bridge. These include abutments, piers, approaches and approach spans, railings, and light standards. It also is possible (although difficult to ascertain) that the significance for some bridges may relate to innovative developments in bridge construction, such as an improved concrete mixture or a new design for bridge "centering," an element that is vital in the construction of arch bridges.

IV-D. Registration Requirements

Reinforced-concrete highway bridges in South Dakota may be eligible for the National Register under Criterion A for their association with events that have made a significant contribution to the broad patterns of American history, South Dakota history, or local history, especially in relation to transportation or regional settlement or development. This includes bridges associated with the designation of "named" or "signed" roads or "trails" and with the design and construction of the earliest designated trunk highways following the 1921 creation of the state trunk highway system.

A bridge in this property type may be eligible for the National Register under Criterion B for its association with a significant person, if that person was not the designer or builder of the bridge.

For a bridge in this property type to be eligible for the National Register, the significant reinforced-concrete element in the superstructure span (i.e., the actual arch, slab, girder, or rigid frame) must be in substantially original condition. Because this engineering element is the most important feature of bridges in this property type, neither an original substructure nor an original deck and railing system are necessary for the bridge to be eligible (although these components, when original, may enhance the significance of the bridge).

Bridges eligible under Criterion A must have integrity of location. Bridges eligible under Criteria B or C may have been relocated, although the likelihood of any reinforced-concrete bridge having been moved is very small.

Most eligible bridges in this property type will fall under Criterion C. They may be eligible for their association with South Dakota or significant out-of-state engineers or engineering firms, builders, or other individuals or firms who made significant contributions to the design and construction of bridges or transportation systems. Bridges in this property type also may be eligible because they embody distinctive characteristics of bridge engineering and construction or significant phases in the evolution of bridge engineering and construction.

Under Criterion C, a reinforced-concrete highway bridge may be eligible if it was or is:

1. Built prior to 1920. Such bridges represent the earliest, pre-standardization, experimental era in reinforced-concrete bridge construction, and are relatively rare. They usually are the product of a pioneering builder or

pioneering engineer. They may represent an overall vernacular construction, both in engineering and architectural design. In terms of age-related significance, such a pre-1920 bridge is the concrete equivalent of a nineteenth-century metal truss bridge.

2. Designed or constructed with patented or otherwise specially designed elements, such as the James B. Marsh rainbow-arch patent. The patented element must be present in the bridge (though not necessarily visible), so it can be recorded and possible preserved if the bridge is removed.

3. Designed at the outer recommended limits for its span type. Such bridges represent extraordinary engineering efforts to push a particular span sub-type to its limits to solve an unusual site problem, and are rare. Generally, the significant span lengths are:

slab span: 20 feet and over, before 1920; 30 feet and over after 1920
through girder: 50 feet and over
deck girder: 50 feet and over, before 1921; 60 feet and over after 1921
arch span: 100 feet and over
rigid frame: 50 feet and over

4. Designed with outstanding architectural style or ornamentation. These bridges represent extraordinary aesthetic efforts to enhance a crossing at an important location. They usually are found in prominent urban settings, such as city approaches and entrances, and in park settings, either urban or rural. These bridges may demonstrate formal styles. Usually these are arch bridges, but a rare type is a girder bridge designed to resemble an arch bridge. An eligible bridge will retain considerable architectural integrity. Original light standards often have been removed; this does not make them ineligible, but original light standards do enhance significance.

5. Designed by a South Dakota Engineer and/or constructed by a South Dakota Builder. Even though out-of-state bridge builders did not dominate the concrete bridge building market in South Dakota to the extent they did the metal truss market, documentation of concrete bridge builders is relatively rare.

6. Designed by an Important Out-of-State Engineer and or Constructed by an Important Out-of State Builder. The following have been identified by this survey as significant in South Dakota bridge-building:

Marsh Engineering Co.
N.M. Stark & Co.
Ward and Weighton.
Additional names should be added as future work warrants.

7. Early Examples of South Dakota State Highway Commission Standardized Designs Such bridges represent the first efforts of state government to improve the quality of bridge construction in South Dakota.

8. A bridge documented as being constructed through a New Deal agency (e.g., WPA) Few New Deal concrete bridges appear to have been built in South Dakota. Bridges with design integrity are eligible.

9. Only Examples of a Type. Such bridges represent rare examples.

I-E. Name of Property Type: Masonry-Arch Bridges[2]

II-E. Description

For the purposes of this discussion, a masonry-arch highway bridge is understood to be a curved, bow-like structure formed of individual blocks, or "voussoirs," which originally (1) spanned an opening on a public thoroughfare, convex-side upward; (2) was engineered primarily for vehicular traffic; (3) produced horizontal and vertical reactions at its supports as a consequence of its load-bearing nature. This definition is specifically meant to exclude bridges with monolithic concrete arches, as well as bridges with primarily decorative, instead of load-bearing, masonry arches -- such as metal-arch bridges with stone facing.

On the basis of materials, masonry-arch bridges fall into three basic categories: stone, brick, and composite -- the last most commonly being a combination of the first two, as in the case of a bridge combining brick voussoirs with stone spandrels and abutments. Composite bridges are especially interesting when they combine different materials for aesthetic effect. In South Dakota, stone-arch structures are the only extant variety.

Compared to the state's metal and concrete highway bridges, South Dakota's masonry-arch structures are of very modest proportions, generally displaying a single arch less than 15 feet in span. Semicircular and segmental forms predominate. Although masonry-arch highway bridges may have been constructed in South Dakota in the 1890s, the oldest surviving example dates from about 1910. The majority of extant structures, however, were built during the 1930s. In terms

[2]The description, significance, and registration requirements for this property type are patterned after those developed by Jeffrey A. Hess in his Multiple Property Nomination for "Masonry Arch Bridges in Minnesota," 1988, on file at the State Historic Preservation Office, Minnesota Historical Society, St. Paul.

of geographic distribution, almost all South Dakota masonry-arch highway bridges are clustered in Turner County, with Deuel and Minnehaha counties having one each. As a general rule, a bridge's material conforms to the local building stone available during its period of construction.

Typical features of South Dakota stone-arch bridges include: rubble masonry with mortar joints of at least one inch; one or two semicircular arches with spans between 6 and 15 feet; simple stone railings, if they exist at all; and an overall structure width of about 18 to 20 feet. These bridges rely on their symmetry and proportions for whatever aesthetic statement they make; ornamentation of any type, including datestone, is rare.

III-E. Significance

With the exception of Turner County, only two masonry-arch highway bridges were identified in South Dakota, and only one of the two [Old Cochrane Road Bridge in Deuel County] pre-dates the New Deal programs. The other bridge [bridge no. 50-315-085] was constructed by the WPA in Minnehaha County in 1936. These two bridges are eligible for the National Register as rare examples of a type.

On the other hand, approximately 185 masonry-arch bridges survive in Turner County from the New Deal era. Turner County undertook a massive masonry-arch bridge construction program beginning in June 1934, and by the fall of 1936 had constructed 65 of the bridges. The stone-arch bridges replaced many of the county's wood bridges. Using work-relief labor, the bridges cost one-fourth of what concrete and steel bridges cost. The county also found the work to be popular with the laborers who could move from location to location every three to four weeks. Obviously, representative examples of these bridges are eligible for the National Register for their association with a significant New Deal program in Turner County.

For the purposes of this survey, the records Turner County maintains for each of the approximately 185 stone-arch bridges were perused. Nine representative examples were selected for field investigation based on multiplicity or length of spans. Each bridge was then visited to determine whether it retained integrity of design.

IV-E. Registration Requirements

The statewide survey of South Dakota bridges identified structures eligible under National Register Criterion A and C.

A masonry-arch bridge loses its integrity when alterations produce a noticeable change in the original design of the masonry arch, or obscure the arch from public view. The most common loss of integrity nationwide occurs from concrete additions, either in the form of a concrete arch which covers an elevation of the masonry arch or in the form of a concrete slab which overhangs the masonry arch to such an extent that it is no longer visible.

Masonry-arch bridges should also retain integrity of location. Although masonry structures are not easily transported, it is conceivable that a bridge might be relocated by either moving it in one piece, or by dismantling and then reassembling the stones. In either event, much of the bridge's significance is likely to be destroyed. Masonry-arch bridges are highly site specific. Unlike metal truss bridges, which were designed to facilitate reuse at other sites, a masonry-arch bridge was engineered as a "permanent" improvement for a single location. In the same way that the arch's rise and span answered the demands of specific terrain, so the details of its construction customarily reflected the use of local materials by local craftsmen.

G. Summary of Identification and Evaluation Methods

Discuss the methods used in developing the multiple property listing.

Selection of Bridge Sample for Field Survey

The Scope of Work for this project did not include a field inventory of all bridges in South Dakota built prior to 1941. Rather, it called for inventorying a select sample. Renewable Technologies, Inc. (RTI) selected a sample of bridges for field survey based on an analysis of the several classes of bridges listed in the South Dakota Department of Transportation (DOT) data base of bridges. The first step in RTI's process of selecting bridges for field survey was done through analysis of computerized lists. Based on preliminary historical research, RTI established several important historical facts: bridge-building companies were responsible for almost all bridge design prior to 1915; there was some influence on bridge design by the State Highway Commission (SHC) between 1915 and 1920; the Bridge Department of the SHC was in full operation from 1920 onward; and J.E. Kirkham's tenure as the first bridge engineer at the Bridge Department ended in

[XX] See continuation sheet

H. Major Bibliographical References

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[XX] See continuation sheet

Primary location of additional documentation:

- [ ] State hisoric preservation office
- [XX] Other State agency
- [ ] Federal Agency

1927. Therefore, RTI first asked DOT's computer programers to divide the 1,930 bridges into four lists: 1) those built before 1915, 2) those built 1915-1919, 3) those built in 1920-1927, and 4) those built after 1927. Within each time period, bridges were arranged chronologically by type. From analysis of these lists, RTI began to make decisions about which bridges to select for further consideration for field inventory.

RTI looked at the Department of Transportation's "Structure Inventory & Appraisal" (SI&A) files for all truss and arch bridges, as well as for all bridges said to be constructed prior to 1920. RTI was more selective about bridge types built after 1920 (concrete slabs, concrete girders, steel stringers and girders, timber stringers, combination steel and concrete girders) which have less engineering significance. Because they represent the beginning of standardized bridge design on the part of the State, and because of the importance of Kirkham to the development of the design, RTI decided to look at examples of these structural types which were erected in 1920 or soon thereafter. RTI looked at bridges which are especially long, either because of their long span or because they are comprised of multiple spans. The SI&A data sheets were reviewed for all of the bridges described in this paragraph.

The next task was to identify other bridges potentially worthy of field inventory. For example, when a truss bridge is "reconstructed," the truss itself may still be intact. Therefore, RTI reviewed data sheets on all truss bridges said to be built before 1941 and reconstructed after that date. For other types of bridges, such features as abutments and piers, guardrails, and the deck constitute important aspects of integrity. This is because the structural systems do not lend themselves to engineering significance, nor are they highly visible. Therefore, RTI determined that if a bridge of a type other than a truss had been reconstructed after 1940, it would not be eligible for the National Register because of a lack of integrity. To attempt to compensate for inaccuracy in the dates given on the data sheets, RTI reviewed data sheets for all trusses said to have been built after 1940. To compensate for inaccuracies in coding of structural type, RTI looked through photos of other bridges from the bridge files. If a bridge looked like it had exceptional integrity or was of a structural type meriting further examination, RTI checked the SI&A sheets to see if it was already among those under consideration. From each bridge file, RTI examined photographs, xeroxed at least one sheet of photos for further analysis, and xeroxed any other material of historical value, such as plans or correspondence. By this method, RTI developed a collection of photos and data sheets for more than 800 bridges to be further analyzed.

RTI next divided the 800 bridges into more detailed categories for bridge types. For example, through trusses were divided into groups of pin-connected Pratts, riveted Pratts, Warrens, Pennsylvanias, etc., and pony trusses into groups of half-hip Pratts, riveted Warrens with horizontal upper chords, riveted Warrens with polygonal upper chords, pin-connected bedsteads, riveted bedsteads, etc. Based on numbers of South Dakota bridges in each category and the expected relative age or engineering complexity of bridges in each category, RTI then made decisions about which categories merited complete survey and which merited selected sampling. RTI decided that all bridges in the following categories should be surveyed:

Pin-connected Pratt through (50)
Riveted Pratt through (6)
Warren through (4)
Parker through (15)
Pennsylvania through (1)
Deck trusses (2)
Pin-connected Warren pony (1)
Masonry arch (5)
Lattice pony (3)
Concrete Rainbow arch (3)
Unusual bridge types (11)

There are 102 bridges in these categories. Of that total, 77 are through trusses. These were all surveyed because most of them date from the period before the SHC began to standardize bridge construction in the state. Furthermore, as a group they represent the height of accomplishment of the early industrialized era of bridge construction. Deck truss bridges merit survey because of their small number and large size. Pin-connected Warren trusses are very rare. The masonry arch represents a pre-industrial technology that has all but disappeared from use. The lattice ponies are quite small, but represent an unusual approach to short-span, metal truss design. The Rainbow Arch is important in the history of reinforced concrete bridge design and construction. The unusual bridge types merit field inventory because they are anomalies.

Categories of truss bridges other than those listed above had to be further examined for selection of representative samples. The first step in selecting bridges for further consideration was to inspect photographs for obvious compromises of integrity. That left pony truss bridges in the following categories:

Pin-connected Pratt (38)
Riveted Pratt (6)
Pin-connected Half-hip Pratt (65)
Riveted Half-hip Pratt (1)
Half-hip Pratt, two-panel (5)
Pin-connected bedstead (24)
Riveted Warren, pre-1920 (96)
Riveted Warren, 1920 (12)
Riv. Warren, post-1920 (54)
Kingpost (18)
Riveted Parker (2)
Pin-connected Queenpost (26)

Riveted bedstead (54) Riveted Queenpost (18)
Riv. Warren, polygonal upper chord (17)

For these categories of pony truss bridges RTI used different selection procedures for those built before 1920 and those built in and after 1920. Because bridges built prior to 1920 represent the varying approaches to design and construction of the bridge-building companies which were active in South Dakota, RTI wanted the distribution of the sample to be as wide as possible, allowing examination of a large assortment of county records. When possible, RTI also selected bridges representing a range of size and dates of construction. On the other hand, truss bridges built after 1920 are based on standardized SHC plans, so there is little need to survey large numbers of them over a wide geographical area. Consequently for post-1920 truss bridges, RTI selected a limited sample representing the earliest and/or longest examples.

The selection of stringer, girder, and slab bridges differed significantly from that for truss bridges because the basic structural features of the non-trusses offer almost no discernible variations in photographs. Judgement of historical integrity must be based on secondary aspects, primarily the guardrails. Several guardrail types are common and are well represented in the final selection. These include solid concrete with recessed panels or incised lines, balustrade guardrails, gaspipes set in concrete posts, and lighter iron railings of angle sections or lattice. To reduce the total number of bridges in each structural type down to a sample for survey, RTI selected bridges representing several characteristic features, such as apparent age, length, and guardrail design.

The 408 bridges selected for field survey included all of the bridges which appeared to have engineering significance, plus representatives of other types of bridges which, although they do not possess engineering significance, were used with frequency and therefore were important to the history of South Dakota's development of a statewide transportation system.

Field Recording

Field recording of each bridge consisted of completing a field survey form and taking photographs. The single-page form included a sketch of an elevation of the bridge and detailed notes on elements such as the composition of chord members, struts, bracing, floor system, and substructure. Generally, each bridge was recorded in three standard photographic views: 1) an elevation, 2) a three-quarters view, and 3) a portal view (along the axis of the road). Special features such as builders' plates, unusual chord intersections, floor beam connections, or portal configurations merited extra photos.

During the actual field inventory, RTI discovered that some of the bridges selected had been demolished since the DOT last updated its data base. During the field inventory, RTI also encountered several bridges that, based on local historical research, appeared to merit inclusion in the sample. These were inventoried and added to the sample. Following is a list, arranged by structural type, of the 402 bridges that RTI field inventoried:

Structural Type	Number
*** Deck Trusses**	
Pin-connected Pratt deck	1
Riveted Warren deck	1
*** Through Trusses**	
Pin-connected Pratt through	51
Pin-connected Parker through	3
Pin-connected Warren through	3
Hybrid (Pratt & Warren) thr.	1
Pennsylvania through	2
Riveted Pratt through	6
Riveted Parker through	13
Riveted Warren through	3
Riveted lattice through	1
Moveable (vertical lift)	1
*** Pony trusses**	
Pin-connected Pratt pony	50
Pin-con. 1/2-hip Pratt pony	25
Pin-connected bedstead pony	14
Pin-con. "queen-post" pony	4
Pin-connected Warren pony	1
Pin-connected king-post pony	8

Structural Type	Number
*** Steel Stringers & Girders**	
Steel stringer	18
Steel str. with outer conc.	6
Steel deck girder	2
Steel through girder	1
*** Steel Arch**	
Multi-plate arch	2
*** Timber**	
Timber stringer	4
*** Masonry Arch**	
Stone arch	11
*** Reinforced Concrete**	
Concrete deck arch	15
Concrete slab	16
Concrete box culvert	1
Concrete deck girder	10
Concrete cantilever girder	1
Concrete through girder	1
Concrete T-beam	1

Riveted Pratt pony	16	
Rainbow arch	3	
Riveted Parker pony		2
Riveted 1/2-hip Pratt pony	2	
Riveted "queen-post" pony	3	
Riveted bedstead pony	1	
SHC "bedstead"		14
Riveted Warren pony		70
Riv. Warren pony, polyg. u.c.	10	
Riveted king-post pony	1	
Riveted lattice pony	3	

Research

The main governmental sources of historical data on bridges built before the State began setting administrative and design standards in 1920 are records of counties and incorporated cities. The hand-written or typed minutes of county commissioners' meetings often include frequent mention of bridges among discussion of topics such as roads, budget matters, drainage ditches, assistance for the poor, wolf bounties, and school district boundary rulings. In some South Dakota counties, the minutes of the county commissioners' meetings reveal only vague information about bridge construction, with little or no data concerning individual bridges. Consequently, for some bridges, the only historical information obtained was from the DOT SI&A files, the historical accuracy of which much be questioned (when local government records did indicate when bridges were built, the dates of construction on the SI&A sheets were often shown to be in error). Other county commissioners' records offer detailed information: petitions from residents for new bridges, accounts of discussions and disagreements concerning projects, specifications, lists of bidders, and details of construction and completion. As a rule, once counties moved to the system of awarding annual contracts for bridge construction, the minutes yield less information concerning individual bridges, although some records do provide annual lists of bridges built, including location, type, and length of span.

City governments also built bridges and have records which provide historical data; these records were also consulted as appropriate. Additional sources on specific bridges included published histories of cities and counties, government publications and reports, articles in technical texts and journals, manuscript collections of the South Dakota State Highway Commission at the South Dakota Cultural Heritage Center Archives, and newspapers.

Eligibility for Listing in the National Register of Historic Places

In determining the eligiblity of the bridges surveyed, RTI followed the guidelines set forth by the National Register in its "Bulletin 16." RTI prepared an historical context and an evaluation of property types, which comprise the two major sections of this report. Using the context and the registration requirements developed for the property types, RTI evaluated each bridge, finding some eligible and other not eligible. The South Dakota Department of Transportation's Historic Bridge Task Force met to consider the list recommended by RTI and decided to ask RTI to prepare a Multiple Property Nomination for a somewhat smaller group of bridges, as per RTI's contract for this project. RTI has prepared nominations for all of those bridges except those that were already listed previous to this project.

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