NPS Form 10-900-b
(Jan 1987)

OMB No. 1024-0018

RECEIVED
MAY 1 1992
NATIONAL REGISTER

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

Highway Bridges in Nebraska 1870 - 1942

B. Associated Historic Contexts

The Evolution of Nebraska's Highway Bridges 1870 - 1942

C. Geographical Data

State of Nebraska

___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.

DSHPO | 5/6/92

Signature of certifying official | Date

Nebraska State Historical Society

State or Federal agency and bureau

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

for Patrick Andrus | 6/29/92

Signature of the Keeper of the National Register | Date

E. Statement of Historic Contexts

Discuss each historic context listed in Section B.

I. Natural Challenges to Bridge Design

Waterways in abundance, unstable soil conditions, and dramatic extremes in weather combine to test the creativity of bridge builders in Nebraska. Two rivers serve as primary obstacles to overland travel: the mighty Missouri, which defines the state's eastern boundary, and the broad Platte, flowing easterly and bisecting the state north from south. The Niobrara and Republican Rivers, together with the Platte, are the state's principal drainage basins. These rivers, with dozens of tributaries large and small, have led some to assert that Nebraska has "more miles of surface streams than any other state in the continental United States."[1] Waterways permeate every sector of Nebraska's varied topography, from the sand hills covering the state's northwest quarter to the Missouri River's alluvial plain. The character of these waterways is as varied as the bridges built to cross them. Bridge design requirements change in response to topography. A very different structure, for example, suits the Platte, which Mark Twain described as "a mile wide and an inch deep," than is appropriate for the deep canyon carved by the Niobrara. Innovative substructure design is necessary to support these diverse structures in areas where bedrock is difficult to reach, as is true in many areas of Nebraska.[2]

Nebraska's climate challenges every bridge in the state. Temperatures ranging from 30 degrees below zero to over 100 degrees Fahrenheit tax structural members and expansion joints. Precipitation also fluctuates: Omaha recorded 45.7 inches in 1881, but a mere 14.9 inches in 1934. Before construction of flood control projects, spring flooding and erratic summer rains frequently swept away bridges. According to a 1936 report, "records show that many river bridges have been reconstructed from three to six or more times." Some of this turnover was the result of structural upgrading, but much was because of high water damage.[3]

II. Early Trails, Early Bridges, Early Technology

Establishing trails and roads across Nebraska was crucial to the region's development. Initial settlement clung to the banks of the Missouri River, which featured regular steamboat traffic by 1831. Most waterways in the area, however, were too shallow and irregular for river borne commerce.[4] If the area's vast interior was to be exploited, it would have to be done by land. Fortuitously, the Platte Valley became the link between the continent's well-established East Coast and the burgeoning West.

Although explorer Robert Stuart recognized the potential of the Platte Valley as a wagon route as early as 1813, it was not until 1830 that William Sublette directed the first wagon train along what was to become the Oregon Trail. Soon the California and Colorado gold rushes and the Mormon migration in the mid-19th century lured hundreds of thousands to make the long journey. A contemporary observer, missionary Father De Smet, marveled that "these pioneers of civilization have formed the longest, broadest and most beautiful road in the whole world... No blade of grass springs up upon it so unceasingly is it trodden by the feet of thousands." Historian James C. Olson has created an apt metaphor for the area flooded by this stream of humanity: "The broad, flat valley of the Platte with its easy ascent to the foothills of the Rockies provided westward-moving Americans with one of the world's great natural highways, and the Platte Valley became the funnel through which America literally spilled over into the West."[5]

The Oregon Trail started at Independence, Missouri, cutting across Kansas to enter Nebraska near the southeast corner of present-day Jefferson County. From there it proceeded across Thayer, Nuckolls,

x See continuation sheet

Clay and Adams counties to the south bank of the Platte River opposite Kearney, turning west to ford the South Platte at Brule. The route then followed the south bank of the North Platte to Wyoming. Another trail, known as the California Trail, went west from Council Bluffs/Omaha, paralleling the north bank of the Platte and North Platte. Yet another early trail connected Nebraska City to Fort Kearney. The discovery of gold in the Black Hills in 1874 stimulated the development of a trail heading northwest from Sidney, then the terminus of the Union Pacific Railroad.[6]

Initiated by private citizens and business interests, these nascent roads were often far from the shortest distance between two points. Tracks were rutted, and bridges were rare. Freighting companies grew frustrated by low-quality and inefficient routes, and felt significant financial incentive to promote improvements. Alexander Majors, partner in a firm which dominated military freight hauling by the 1850s, needed a better route from a terminal in Nebraska City to Ft. Kearney. In 1860 he hired August Harvey, a civil engineer, to survey and establish a direct road to replace the existing, roundabout trail. A note on Harvey's 1862 map outlining the new route proudly announced: "This road worked and opened in 1861 - every stream bridged - no fords - no ferries."[7]

The federal government focused its initial road-building efforts on the east side of the Missouri River. In 1820, Congress authorized construction of a military road from Grand River, Missouri, to Council Bluffs. U.S. troops under the direction of General Atkinson built the 300-mile stretch. It was not until 1855, the year after the west side was opened for settlement, that Congress approved a road from Omaha to Fort Kearney, which presumably upgraded the earlier pioneer trail. The 168-mile road was built by the Engineer Department between 1855 and 1861 at a cost of $49,993.37. U.S. Highway 30 now follows the same general route. Shortly thereafter, the federal government authorized a road from Fort Riley, Kansas, to Fort Kearney along the Republican River, and from Niobrara to Virginia City, Montana.[8]

Since Congress could not keep up with the task of extending roads to the rapidly developing frontier, it encouraged settlers to make improvements themselves. The legislation creating Nebraska Territory in 1854 granted county commissioners both the authority and responsibility for opening and maintaining county roads: "All public roads shall be surveyed, opened, made passible [sic] and kept in repair, 40' wide; and all bridges on any public road shall be at least 16' wide, with a good and sufficient railing on each side, 3' high, the whole length of the bridge." Six years later, the roadway width was increased to four rods (66 feet). To fund road construction, a poll tax was authorized for men 21 to 60 years of age, with the provision that two days of labor could be substituted for cash payment. The territory's first legislature, which convened in 1855, established ten territorial roads and incorporated a number of bridge and ferry companies.[9]

Little is known about actual bridge construction practices of the territorial era. No bridges survive from this period, and even documentary evidence is rare. It seems fairly certain, however, that the legislature's initial dictates about bridge width and railing height were largely ignored, since state authorities were struggling to implement similar measures fifty years later. In all probability, territorial bridges in Nebraska resembled structures being built in other newly settled regions of the Midwest:

for little traveled crossings, simple timber stringers; for more important locations, standard truss types of wood and iron, known as "combination bridges" because of their mix of materials. As was common in cash-poor areas, Nebraska settlers preferred to repeatedly reconstruct inexpensive timber bridges rather than invest in more permanent - but expensive - metal and masonry structures. The ultimate example of cheap (and presumably short-lived) bridges were those crafted by resourceful prairie pioneers from a readily available material: sod.[10]

As Nebraska's population grew, pressure mounted to erect bridges at larger waterways crossed by ford or ferry. In 1871, four years after Nebraska achieved statehood, the legislature created a bridge fund to pay interest on county-issued bonds for bridges over the Platte. The fund was financed by the sale of fifty sections of government land. John L. Means of Grand Island, credited by early 20th century engineer Guy Dorsey as "probably the greatest of all early big stream bridge builders" in the state, was responsible for most of the early Platte bridges, including "a high truss combination span at Ashland, under-truss spans at Schuyler, Central City, Columbus and 'Twelve Bridges' at Grand Island, so-called because it required twelve individual bridges to span the channels and islands at that crossing." The bridge at Grand Island, erected in 1878, may have been the 4200-foot-long, 10-foot-wide structure that served traffic until replaced by a state aid bridge in 1919. The Central City structure, probably of a similar age and stretching 5080 feet, also stood until 1919. The longevity of these bridges was unusual, given the waterway's periodic rampages. Ice jams and floods in 1881, for example, annihilated every bridge on the Platte below the mouth of the Loup, and left only a few survivors upstream.[11]

As in road development, private interests often were the moving force behind bridge construction. An example is the North Platte bridge on the Sidney/Black Hills Trail built in 1876 by Henry T. Clarke, with financial assistance from the Union Pacific Railroad and investors in Omaha. The value of this improvement is apparent from a freight driver's recollections of the earlier ford:

> **A sight worth seeing and well remembered was that of three full ox-teams of seven yoke in each team - 21 yoke in all - stretched out across the North Platte River on the old Sidney Trail, attached to [a] single wagon loaded with supplies, hauling it through the stream in flood with a bottom of treacherous quick sand.**

Relying on the venerable kingpost truss form, much used by mid-19th century bridge builders, Clarke's combination bridge was a series of wooden "A" frames with iron rod hangers. It was apparently of sturdy construction: one writer recalls that "the trusses of this bridge were in good condition after ten years of the Black Hills traffic and twenty-three years of service." If sections were torn away by ice or floods, they could be easily replaced. The second bridge over the North Platte was built at Chimney Rock in 1892 by Robert Z. Drake, who bought out John Means' bridge business in 1902 and established the Standard Bridge Company, one of the most important bridge building firms in Nebraska history. Another pair of major bridges was built by John Burke, who settled in Lincoln County in 1864 and was one of the first in Nebraska to experiment with irrigation. He built a bridge across the mouth of the South Platte and, later, bridged the Platte to expedite movement of freight from the Union Pacific Railroad station on the north bank to Fort McPherson on the south. None of the 19th century Platte River bridges have survived.[12]

III. From Wood to Steel: Development of Design and Materials in the 19th Century

The gargantuan bridges over the Platte and its forks displayed typical engineering practices of the day. Combination spans were also used on more modest bridges over smaller streams. Dorsey, writing in 1931, reports that "the earliest combination wood bridge of which we find record in Nebraska is a 40 ft. narrow Howe truss on stone abutments on the Iron Bluff and Omaha Road in Douglas County erected October, 1867."[13]

Patented by William Howe of Massachusetts in 1840, the Howe truss featured wooden diagonals in compression and iron verticals in tension. Another important truss design, patented by Thomas and Caleb Pratt in 1844, reversed the stress pattern of the Howe, making verticals stand in compression with diagonals in tension. Although originally made of wood and iron, this design adapted well to steel construction. Because of its simplicity and adaptability, through and pony Pratts quickly became ubiquitous throughout most parts of the United States. In Nebraska, the Pratt and various modified designs rode a wave of popularity well into the 20th century. Nebraska proponents of the Pratt resisted its replacement by the Warren truss, another mid-19th century invention. Patented by English engineer James C. Warren in 1848, the Warren truss is characterized by diagonal members in both compression and tension. By the early 20th century, the steel Warren truss dominated bridge construction in many areas of the United States, but it never swept Nebraska. Some of Nebraska's surviving examples were, in fact, moved in from nearby states. Apart from indigenous concentrations of Warren pony trusses in Gage and Custer counties, this type is relatively rare in Nebraska.[14]

Evolution of truss components and connections paralleled that of truss design. Pins were first used to connect metal truss members on a Lehigh Valley Railroad bridge in 1859. Two years later, a complementary truss member, the wide, forged, iron eyebar, was introduced. Eyebars of steel appeared in the 1870s. Pin connections, typically used on Pratt trusses, allowed quick erection, but were a weak point structurally and could loosen from vibrations caused by traffic and wind. Riveting created a stronger, sturdier means of connection, but was not practical in the field before portable pneumatic riveting systems became available in the late 1880s. This technological breakthrough boosted the popularity of Warren trusses, which were usually of riveted construction. Some early 20th century Pratt trusses took advantage of riveting as well.[15]

Although Pratt and Warren trusses were the most common metal bridge types in the late 19th century, a number of other styles appeared in Nebraska during the period. Historian Dorsey identifies the state's first all iron bridges as a 100-foot bowstring arch in Tecumseh over the Nemaha, and a similar structure in Otoe County, both erected in 1869 on a road between Nebraska City and Beatrice. The Tecumseh bridge was replaced by a through truss in 1892, and the Otoe County bowstring was moved in 1926 to a new site seven miles south and one-and-one-half miles east of Nebraska City. Neither has survived, but Otoe County has three bowstring arches (NEHBS No. **OT00-88, OT00-89, OT00-90**) that date from 1874, 1876 and 1878, respectively, and Beatrice in Gage County has a bowstring (**GA00-47**) that apparently dates from the early 1870s and originally stood at Blue Springs. A bowstring arch bridge was shaped as its name implies: a curved upper chord was tied at each end to the lower chord. The design was patented in 1841 by Squire Whipple, an influential mid-19th century engineer who published the first major American treatise on truss bridges six years later.[16]

The mobility of metal trusses is an important trait. Nebraska civil engineer Jack Singleton, writing in 1931, noted that "tin" bridges were often "removed from their original sites to make way for newer, heavier, more modern structures, and have been re-erected at other locations where they may continue in service." Movement of a structure such as the Blue Springs/Beatrice bowstring, thus, does not necessarily detract from the historic integrity of a truss bridge.[17]

Relocation was not possible with leg bridges and bedstead trusses, simple spans widely used around the turn of the century. Leg bridges spanned less than 30 feet; bedsteads were typically 30 to 60 feet. As described in a 1902 article entitled "Defective Bridge Construction in the Prairie States," leg bridges were:

> **steel girders, usually I-beams, spanning the opening and supported at each end by uprights or legs of steel I-beams with riveted or bolted connections to the girders and resting upon timber mud sills embedded three or four feet beneath the bed of the stream. A backing of wooden plank, sheet steel, or flagstone, rests against these legs, and supports the earth filling of the roadway.**

Bedsteads featured pony trusses in which "the end post of the truss is extended downwards to form the leg support as in the leg bridge, and is securely riveted to the end of the upper chord member." Designed without provision for expansion and contraction, bedstead structures quickly weakened, making them prone to buckle under the simple pressure of earth fill. Others collapsed because of corrosion. The article's author claimed that the style appealed primarily to short-sighted penny-pinchers who thought: "Let the next generation care for its own bridges."[18]

Remarkably, at least a dozen bedstead bridges have survived into the 1990s in Nebraska. Not so surprisingly, however, most are in very poor condition. Both Pratt and Warren trusses were used. Connections are usually pinned, but some are riveted. Spans range from 35 to 79 feet. The longest (**TS00-81**) is about 20 feet beyond the normal maximum for this style and, also atypically, employs transverse stringers. It was probably built by the Standard Bridge Company, owned by Robert Z. Drake, who claimed to have invented the transverse joist girder bridge. The erection dates of only three bedsteads can be verified: a three-panel Pratt in Butler County built by the Canton Bridge Company in 1897 (**BU00-84**), a Pratt in Cherry County built by the Wrought Iron Bridge Company in 1900 and a Warren bedstead in Lancaster County (**LC00-103**) from 1897, also by WIBCo.[19]

Despite their shortcomings, bedsteads were built, in part, because of the simplicity of their footings. The task of establishing solid bridge foundations was formidable, given the depth of Nebraska's bedrock. Spring ice flows and floods further tested substructures. Early bridge builders preferred to make foundations from red cedar and oak piles, which were strong and relatively resistant to deterioration in water and air, but scarcity sometimes forced them to use any timber available. Although the initiation of rail transport brought access to wood from other markets, such as Southern pine and Western fir, even the best timber substructures remained vulnerable to decay until the widespread adoption of creosote oil as a wood preservative in the early 20th century. No one questioned the durability of masonry substructures, but, for the most part, only large cities and railroads could afford them. Since piers were costly and hard to erect, early Nebraska bridge builders often avoided their use by opting for longer superstructures.[20]

Bedstead bridges were an effort, albeit a structurally flawed one, to use metal for footings. Concrete-filled steel tubes had also been tried, but were felt to be unsafe. Around 1902, however, Robert Z. Drake revolutionized the industry by fabricating a steel pile from two eight-inch channels and a five-inch beam. Within the next decade, I-beam footings and, later, eight-inch H-beam footings became ubiquitous. An engineer in the mid-1930s, reflecting on past years of bridge construction, wrote that "it is interesting to note... that the super-structural styles have undergone an almost complete revolution, while the sub-structural style or type is fundamentally unchanged." Another engineer at about the same time reported the accomplishments of Drake, owner of the Standard Bridge Company: "In the country between the Mississippi River and the Great Divide he alone has erected over 15,000 steel pile structures."[21] It is evident, then, that the last half of the 19th century and the first decade of the 20th century witnessed the evolution of both superstructures and substructures from wood and iron to steel. The first significant use of steel in bridge construction in the United States, the 1874 Eads Bridge across the Mississippi in St. Louis, was perhaps familiar to many in the young state of Nebraska. The first major bridge entirely of steel was also nearby, the Chicago and Alton Railway's Glasgow Bridge, built over the Missouri downstream from Nebraska in 1879. Other major railroad spans comprised largely of steel were erected in the 1880s over the Missouri River at Plattsmouth, Omaha, Blair, Rulo and Nebraska City. By the end of the century, steel had surpassed all other materials for bridge construction in the United States.[22]

Steel had been available since the early 1800s, but its manufacture was laborious, expensive and, in its formative years, often structurally inconsistent. Iron was more economical, and was produced on a large scale. Even though the country's annual iron output climbed to almost one million tons by 1860, that amount was not nearly enough to satiate the demands of railroads, manufacturers, the construction industry, and bridge builders. The Civil War intensified the need for faster and better ways to work iron and, fortuitously, at about that time there were major breakthroughs in converting iron to steel. The first to be utilized on a large scale was the Bessemer process, which required a pear-shaped furnace into which molten pig iron was poured and blasted by air to remove impurities, emerging as molten steel. Bridge engineer and author, J.A.L. Waddell, noted that "Bessemer steel was never popular for bridgework on account of its lack of reliability, and especially because of its occasional tendency to crack under shop manipulation."

Although Bessemer steel was sometimes used in bridge construction, wrought iron continued to dominate the market until 1880. Both materials were almost completely replaced in the following decade, however, by steel produced by the "open hearth" method. This process, which utilized scrap as well as pig iron, surpassed Bessemer steel by creating a product of higher quality and lower cost.

In the meantime, new iron deposits were discovered and mined using innovative techniques to extract the ore and transport it to the mills. By the 1870s, high-grade fuel was provided by commercial production of coke, which burned hotter than its source material, coal, and was more readily available than charcoal. The manufacture of steel in the United States boomed from about 22,000 tons in 1867 to 11.4 million tons in 1900, with the country taking world leadership in production in 1889.[23]

Steel ingots were hammered at a forge, flattened by rolling mills, or recast by a foundry into standard shapes, such as I-beams, angles, channels, and plates, for use in the construction industry. These provided the building blocks for both steel-framed buildings and metal bridges.

IV. Nebraska's Late 19th and Early 20th Century Bridges and Their Builders

Builders of the Platte bridges were primarily local, with designs created by improvisation. Smaller bridges, on the other hand, were usually the product of established bridge companies which bid on construction contracts let by counties. Several companies in the Northeast and Midwest specialized in bridge fabrication. Their salesmen contacted counties where rapid population growth produced a demand for large numbers of bridges. When an order for a bridge was received, necessary components were prepared at the fabrication plant. Bridge fabricators sometimes erected the parts at the site as well. Other firms, particularly local ones, received county bridge contracts but were responsible for erection only, obtaining bridges from the fabricators.

Nationally prominent companies which worked in Nebraska included the King Bridge Company, maker of the bowstring trusses mentioned previously as well as a bowstring in Pawnee County (**PW00-42**), another bowstring in Antelope County (**AP00-3**), a Warren through truss in Butler County (built in 1891, **BU00-83**), a Pratt through truss in Otoe County (**OT00-87**) and a handful of other iron and steel spans. Headquartered in Cleveland, for a short time the company had outposts in Topeka and Iola, Kansas. Other Ohio firms visible in early Nebraska were the Wrought Iron Bridge Company, which had district offices in New York, Chicago, and Kansas City and built the Olive Branch Bridge in Lancaster County (**LC00-103**) in 1897 and the Twin Bridge in Cherry County (**CE00-223**) in 1900, and the Canton Bridge Company, responsible for clusters of bridges that survive in Pierce, Valley and Cherry counties (including **PC00-45**, **PC00-46**, **PC00-47**, **CE00-223**, **CE00-224** and **CE00-22**).[24]

In 1900, J.P. Morgan created the American Bridge Company by consolidating 24 smaller firms, including the Wrought Iron Bridge Company, the Edge Moor Bridge Works (Wilmington DE), the Gillette-Herzog Manufacturing Company (Minneapolis MN), the Milwaukee Bridge and Iron Works (Milwaukee, WI) and the Union Bridge Company (New York NY), all of which had worked in Nebraska. The American Bridge Company subsequently erected many Nebraska bridges, including a swing span at Omaha in 1903, the Meridian Bridge at Yankton (**CD00-256**) in the early 1920s, and the Hastings Subway (**AD04-716**) in 1934.[25]

Regional bridge builders active in Nebraska included James B. Marsh, George E. King, and Nathaniel Stark, all of Des Moines; the Minneapolis Steel and Machinery Company; J.W. Hoover, A.M. Blodgett, and the Kansas City Bridge Company, from Kansas City; and the Missouri Valley Bridge and Iron Works of Leavenworth. In addition, there were many bridge erectors located in Nebraska. Some obtained materials from Eastern firms. Locally, iron and steel were available from several companies including the Paxton-Vierling Iron Works, an Omaha metal works. Most local bridge builders were small contractors who worked in neighboring counties. Some had gained experience as agents for established Eastern firms. The Andrews Brothers, for example, appear in the Omaha City Directory in 1890 and several years thereafter as general agents for the Smith Bridge Company of Toledo, Ohio. In 1894, however, Smith is not represented, but there is a new firm on the scene: the Andrews Bridge Company. Others entered the business through family connections. Harvey Ward's family was involved with the Clinton Bridge and Iron Works, a major Iowa company, for which Harvey was an agent before going into business under his own name. He built bridges in several southeastern Nebraska counties in the late 19th and early 20th centuries, including a through truss in 1892 that replaced the bowstring arch across the Nemaha. He married Mary A. Gilligan, who was probably related to John B. Gilligan, a bridge builder from Falls City.[26]

Some eventually regretted their entry into the field. The Lincoln Construction Company erected state aid bridges at Cambridge and Sutherland in 1914 and several bridges in Clay County in 1915-1916. One of the latter was inspected by an engineer from the state who found that "the workmanship as a whole was decidedly poor... I would recommend that all of the payments on the bridge be held up until the poor appearance... is remedied." In frustration, the company's president, W.S. Collett, declared that "my experience in the bridge business has been more or less disastrous, from a financial point... which leads me to the conclusion that I had better quit while my credit remains good."[27]

Others did quite well. Bridge plates of the Standard Bridge Company, Omaha Structural Steel Works, and the Western Bridge Company, all based in Omaha, can still be seen on bridges throughout Nebraska and in surrounding states as well. Standard, as mentioned earlier, was founded by Robert Zale Drake, who is credited with innovating designs for the transverse joist girder bridge and steel pile substructures. John W. Towle, after working as an agent for Canton Bridge in the late 1890s, established the Western Bridge and Construction Company. While apparently maintaining some involvement with Western, he started up a competing company, Omaha Structural Steel Works, in 1906. A decade later, the steel works covered an eight-acre site and employed over 300. Towle was also instrumental in creating Allied Contractors in 1919-1920, a firm which seems for a time to have taken over construction responsibilities from Omaha Structural Steel.[28]

Many Nebraska counties began contracting for bridges on an as needed basis, but most eventually let annual contracts to a single company for construction and repair services. Representatives from national and regional bridge companies, as well as local contractors, submitted sealed bids based on needs indicated by the counties. County specifications tended to be vague, often stating little more than the location and length of a proposed bridge and, sometimes, the desired material (timber, iron, combination, or steel) or several options. This lackadaisical approach was common throughout the country: as early as 1874, an Ohio wrought iron bridge fabricator complained that the "loose manner" of advertising and awarding contracts did not make for fair competition because:

> each builder would adopt his own standard of load and unit strain, which usually differed from that of his competition, while others had no definite standards, but adopted the 'rule of thumb' practice, so that the bids were no guide whatever to the relative cheapness of the respective bridges, as the bidder who was twenty-five per cent below his competitor in price, may have been fully fifty per cent below him in capacity and weight of iron used, and hence was really the highest bidder in fact.[29]

The state engineer encouraged counties to adopt their own plans, designed by competent engineers, but only a few heeded the advice:

> A few of the counties had their county engineers or surveyors prepare plans upon which to let contracts to build bridges, but in a large majority of the counties the bridge companies furnished plans and specifications for bridges and the company whose plans and specifications were finally adopted by the county were given an unjust advantage over other competitors for the reason that these plans which were put on file were not fully detailed and did not specify clearly and positively the sizes and kinds of material and the method of construction.[30]

Despite this lack of standardization, most of the trusses produced during this period are quite similar: lightweight, pin-connected spans, usually half-hip or full Pratts. There are a few noteworthy exceptions, such as a group of late 19th and early 20th century bridges in Gage County. Thirty-two of Gage's Warren pony trusses survive, including **GA00-43**, **GA00-44**, **GA00-45** and **GA00-46**. The spans were unusual not only for their rejection of the popular Pratt style but also because they combined both pinned and riveted connections. They were also extremely short, most under 35 feet, a situation where stringer spans or half-hip pony trusses were more commonly used. Several firms, including the Youngstown Bridge Company, J.H. Sparks, and Standard, received contracts during the period that these bridges were built, so the unusual plan evidently did not deter competition.

Even when counties used standardized and well-detailed plans provided by the state, there was no guarantee that the product would be superior. Clay County, for example, adopted state plans in 1910. In the following year, despite some debate over the merits of steel trusses, the commissioners ordered three pony truss bridges from a previous vendor, the Western Bridge and Construction Company. There was apparently some doubt about the quality of the construction, because the commissioners asked the state engineer to examine the completed bridges early in 1912. The engineer confirmed their fears, finding that the workmanship was poor and that none of the bridges had been built according to specification. In examining one bridge he discovered that looped eyebars had been substituted for punched eyebars for the lower chord; the angle sections used for verticals and sway bracing were one-sixteenth of an inch too thin; three-inch by twelve-inch stringers were used instead of the four- by sixteen-inch members specified; and bolted field connections were badly done. In fact, he concluded, "as the bridge stands, it is unsafe for a twenty-ton traction engine, and I should hesitate about taking a twelve ton engine across after the bridge has been in service for three or four years."

Shortly thereafter, Western rebuilt the bridge to meet the state engineer's approval. The Big Blue River Bridge still carries traffic one mile east of Harvard.[31]

Another force working against the construction of low cost, high quality bridges was collusion amongst the bridge builders, which has been well documented in neighboring states. Agents for bridge companies met before annual spring contract lettings and split up the territory. Companies not designated to receive the contract in a given county would bid somewhat higher than the anointed company, and the county commissioners would innocently award the contract to the lowest bidder, not realizing that the outcome was predestined. Indeed at other times, the commissioners' decision was not so innocent.[32]

There is evidence of collusion in Nebraska as well. Commissioners in Richardson County, who had been doing business for a number of years with the John B. Gilligan Bridge Company of Falls City, rebelled in 1906. The Bridge Committee exclaimed that "the bidders who were supposed to be competitors of the John Gilligan Bridge Co. were mere stool-pigeons imported here for no other purpose than to drag the game into the net." For some years thereafter, the county itself took over responsibility for bridge construction. York County had similar doubts about the competitiveness of its bidders when it awarded its annual bridge contract in 1916 to the Western Bridge and Construction Company. Fearing that they were paying more for comparable structures than was neighboring Hall County, the supervisors sought advise from the state engineer. It was only after the state engineer told them that their prices compared favorably with other counties' that the supervisors awarded a contract to Western.[33]

The bridge cabal apparently schemed to extend price fixing to the state level, too. The Nebraska Board of Irrigation's 1910-1912 *Biennial Report* revealed that competition seemed genuine for all of the State Aid bridge contracts "with the exception of the first-attempted bridge letting at Springview, Keya Paha County, where the bids seemed to indicate previous agreement between the bridge companies represented." Detected but not defeated, the companies apparently made another attempt when the Carns State Aid bridge went out for bid: "From the bids received it was evident that there had been no competition in the bidding and the bids were all rejected."[34]

Supervision of construction and subsequent maintenance was also haphazard for both roads and bridges, especially when it was the responsibility of townships. As late as 1912, the state engineer complained:

> **At present the major portion of the money which is paid out upon the roads is expended under the supervision of road overseers. These road overseers are almost invariably men who have little or no knowledge of the proper methods of road construction and who are elected by the voters of their township without any regard to their qualifications.[35]**

While bridge design and construction practices were, for the most part, similar from county to county, this was not the case in Omaha. A.S. Morgan was hired as the city's first engineer in 1855. One of the most influential men to hold that position in the late 19th century was Andrew Rosewater, who started his career as a rodman on a crew exploring potential transcontinental rail routes through the Rocky Mountains. He was hired as Omaha's assistant city engineer in 1868, and, after a short stint as Douglas County surveyor, became Omaha's chief engineer in 1870, a position he held at various times until his death in 1909. In addition to developing the city's water and sewer system, Rosewater spent a good deal of energy dealing with ways to separate rail and other traffic. By 1892, the city had four major viaducts at Tenth, Eleventh, Sixteenth, and Park streets, with construction of another planned at Hamilton. According to the city charter, the city could order railroads to build viaducts over their tracks. Railroads often objected to the expense, and procrastinated on construction. Such was the case, for example, in the 1890s when a new structure was needed to replace the earlier Sixteenth Street Viaduct. After long haggling with the railroads over repairs on the old structure and armed with the railroads' grudging consent to build a new viaduct, the city council in May 1899 resolved that "unless the U.P. and B & M Ry. Cos. do file with the City Engineer complete plans for the new 16th St. viaduct, as agreed upon by said R.R. Companies and the City Engineer, together with the agreement to build the same without any delay... the City Attorney be and is hereby directed to begin legal proceedings" against the railroads. Apparently, the strong-arm tactics worked: about a year later, the new viaduct opened. The city also paid for some viaducts, and the city engineer often drew up plans and specifications, even if railroads were responsible for construction.[36]

Omaha impressed not only Nebraska but other states along the Missouri River when it became the site of the first permanent bridge across that waterway in 1872 - although the Union Pacific, not the city, was responsible for its construction. In 1887-1888, the Council Bluffs and Omaha Railway and Bridge Company erected a bridge for streetcar and other vehicular traffic, an iron truss structure which, with approaches, measured nearly a mile. The "electric motor line" offered "great advantages for rapid transit between the two cities... the trip, seven miles, being made in twenty-nine minutes."[37]

In 1893, the Omaha Bridge and Terminal Railway Company built a 1,620-foot-long interstate bridge, designed by J.A.L. Waddell and fabricated and erected by the Phoenix Bridge Company of Pennsylvania. The central, 520-foot swing span was designed to carry two rail tracks between the truss webs, with two lanes for use by electric streetcars and other vehicles and two sidewalks cantilevered outside. A contemporary writing in *Engineering News* declared that the central span "is the largest and with one exception the heaviest swing span in the world," weighing in at about 3,000,000 pounds. The other spans were intended to be temporary and carried a single track, with provision for vehicular and pedestrian traffic. In 1903, the temporary construction was replaced by another swing span. Although only separated by a decade, the two spans reflect major changes occurring in bridge construction at that time. While all castings on the earlier swing span were iron, all on the new span were steel. Bracing was more rigid in the new span, and structural members heavier, to support a greater live load. Waddell again designed the structure; the American Bridge Company built the superstructure. Waddell also designed another swing span further upstream at Sioux City, Iowa, in 1896-1897. Built by the private efforts of the Combination Bridge Company, the bridge cost about $1.2 million and included two 500-foot, fixed, through trusses and two 470-foot swing spans. It carried two traffic lanes and a rail track.[38]

The state's road system, however, was becoming too important to leave in the hands of private interests. As cars, trucks, and farm machinery grew in number and weight, the demand for good quality roads and bridges became more and more pressing. As engineers became more professional, they insisted that related industries keep pace. For example, Waddell wrote in 1915:

> It became evident that while the old competitive system of lump-sum bids by the various bridge companies on their own plans had played its part in developing economic design in America, for best practice it had become a thing of the past. In the words of noted engineer C.C. Schneider: "The manufacturer should confine himself to his legitimate field of manufacturing steel at so much a pound."[39]

State government, ready or not, was faced with coordinating the efforts of local governments, private groups, and, soon, the federal government, to develop a transportation system that would bring Nebraska from horse-and-buggy days into the gasoline-powered 20th century.

V. The Influence of the Railroads

Railroads catalyzed the settlement of the West, which led to burgeoning demand for roads and bridges in the last half of the 19th century. Railroad engineers pioneered the use of new materials, developed bridge designs, and upgraded construction standards. These innovations were soon borrowed by highway bridge builders. Indeed, many bridge engineers who honed their skills in the service of railroad companies established private engineering practices and became consultants to highway departments. To understand this period of highway bridge development, therefore, it is necessary to examine the contribution of the railroads.

The stimulus to create Nebraska Territory came, in large part, from politicians and businessmen in Iowa, Illinois, and points east who wanted the privilege - and the concomitant economic benefits - of having the transcontinental railroad go through their states. Over a decade of squabbling by proponents of the various proposed routes ended in December 1863, when President Lincoln determined that the eastern terminus of the Union Pacific Railroad would be at Council Bluffs. Progress was slow at first - only forty miles were completed through 1865 - but the track passed Kearney by the following August and North Platte by November. A year later it reached Cheyenne, Wyoming. The final spike connecting the country by rail was driven in Utah in May 1869.[40]

The advent of cross-country rail travel led to the gradual extinction of slower, and often less comfortable, means of transit, including the stagecoach, wagon train, and steamboat. The grand, seemingly endless pioneer trails across the prairie were abandoned by all but local residents. The most important roads were those radiating out to farmlands from new towns founded and ambitiously promoted by the railroads. George Johnson, an early Nebraska state engineer, remarked that "as soon as the great railroad development was started in the State, people lost interest in road construction." The state did not participate in road construction from 1876 until 1911.[41]

It thus comes as no surprise that railroads claim credit for nearly all innovation in bridge design and construction in the late 19th century. From their inception, railroads needed reliable bridges to protect their investment in rolling stock and to keep schedules running smoothly. Bridge engineer Waddell asserted that "the introduction of railroads in the United States came in 1829, and with it began the real development of bridge engineering." Another engineer, Jack Singleton, observed that "the railroads are usually first in developing a country and they learn from experience the peculiarities and eccentricities of a stream."[42]

The Missouri River qualified as one of the most eccentric waterways in the country, and the Union Pacific was the first to conquer it, initially with a temporary timber structure at Omaha in 1870 and then, two years later, with a permanent, single-track, iron truss railroad bridge. The difficulty in accomplishing this feat is reflected in the structure's $2.9 million price tag, a truly gargantuan sum in that era. According to a late 19th century description in *Engineering Record*, the bridge "consisted of eleven spans of 250 feet each... The late T.E. Sickels was chief engineer. The original superstructure was of the Post pattern for a single track, with trusses 28 feet deep, divided into 22 panels; the web was of the triple-intersection system." The article cited the bridge as "the most prominent example in America of the Post superstructure and pneumatic cylinder piers."[43]

The first Post truss bridge was built for the Erie Railroad in 1865, and the style was in vogue for the next fifteen years. Designed by S. S. Post, it was essentially a Pratt truss in which the verticals inclined toward the center. "Triple intersection" indicates that diagonals stretched over three panels, rather than just a single panel as in typical Pratt trusses. Proponents of the Post style asserted that it offered an extremely rigid and sturdy structure, but that claim was quickly disputed by the Omaha bridge. The structure had no horizontal bracing on the top or bottom of the trusses or at the portals and, not surprisingly, two of the bridge's eastern spans were blown down in a storm within a few years of its completion. As historian Carl Condit observed: "This remarkable exhibition of daring and ineptitude was as noteworthy for its short life as for its great size and unusual construction."[44]

One span of the Omaha bridge was replaced by a trestle, the other by another modified Pratt known as a double-intersection truss, in which diagonals crossed two panels. Double-intersection trusses are often called Whipple trusses after Squire Whipple, who first developed the design for the Saratoga and Rensselaer Railroad near Troy, New York, in 1852, and who was also responsible for the first bowstring arch-truss. A 19th century engineering journal described the advantages of the design:

> **In the case of trusses of comparatively small span, this double system of bracing has the advantage of making a more rigid girder, and one better calculated to withstand the racking effects of a live load, whilst in the case of large spans, the joints are less clumsy, and the lateral bracing can be more satisfactorily planned.**[45]

The "pneumatic cylinder piers" of the Omaha bridge were also significant. Condit describes them in more detail: "Each pier of the bridge was made up of a pair of cast iron drums filled with concrete, a crude but useful innovation that constituted an early step in the development of the concrete bent." Some of these piers were recycled in 1885 when the volume of traffic and heavier loads prompted the railroad to initiate construction of a new bridge at the same site. This new structure not only included two tracks, but also "a highway and a sidewalk, respectively 7 feet and 3 feet wide in the clear... carried on cantilever arms projecting outside each line of trusses." The cantilevered sections were later removed. The new superstructure, manufactured by the Union Bridge Company at its plant in Athens, Pennsylvania, consisted of four pin-connected, 246-foot, Whipple double-intersection through trusses with three 125-foot approach spans at each end. This bridge, in turn, was replaced in 1916.[46]

Waddell remembered George S. Morison as being the last prominent American engineer to use the Whipple truss. Thanks to the efforts of Morison, these trusses were soon a relatively common sight over the Missouri. In the late 1880s, he employed them at Blair when retained by the Missouri Valley and Blair Railway and Bridge Company, and again when engineering bridges for the Chicago, Burlington and Quincy Railroad Company at Rulo and Nebraska City. The superstructure of the Rulo bridge, fabricated by the Edge Moor Iron Company, included three 15-panel, 375-foot Whipple through trusses created from steel, cast iron and wrought iron components.[47]

The age of steel in bridge construction was just dawning during this period, and the inexperience of some producers apparently necessitated special caution on the part of bridge builders. Morison's specifications for the Rulo bridge noted that "steel may be made by the open hearth or by the Bessemer process, but no steel shall be made at works which have not been in successful operation for at least one year." Indeed, even specifications and basic quality control were innovations of this period. Waddell credits Morison's specifications for a bridge for the Erie Railroad, prepared in 1873, as "probably the first printed bridge specifications ever adopted by any American railroad." He added that Morison "required successful bidders to submit stress sheets and plans for approval before starting work, and later began the inspection of materials and workmanship."[48]

Railroads led the way in adopting steel as the material of choice for bridge construction, and devised new designs to take advantage of the material's potential. Railroads also pioneered the use of concrete for bridge piers, as at the Union Pacific crossing at Omaha, and also at a Burlington Railroad span over Pawnee Creek near Ashland, where barrels of Portland cement were imported from Belgium in 1888. In addition, around the turn of the century railroad companies experimented with floor surfaces, such as creosoted wood, and the results were soon transferred to highway bridges as well.[49] An engineer writing in 1929 proclaimed: "There is no doubt that twenty years ago the science and art of bridge design had found their highest expression in railway bridges. Specifications were more adequate, inspection more rigid... than in the highway field." But an upstart, in the form of the unpretentious Model T, would ultimately return roads to the spotlight. The rising dominance of the automobile industry over railroads is figuratively expressed by the caption on a 1924 photo of a new road: "A speedway over which the over-ambitious autoist can pass up the passenger trains on the paralleling Burlington railroad tracks." Necessary improvements in road systems included newer and better bridges. As a result, the first decades of the 20th century would prove a period of profound change for both the technology and bureaucracy behind bridge construction.[50]

VI. Early Government Involvement with Bridges

As discussed above, the federal government became involved in Nebraska's roads and bridges in the mid-19th century. In 1893, a prominent Nebraskan, J. Sterling Morton, then U.S. Secretary of Agriculture, inaugurated the Office of Road Inquiry within his department. The Office initially received an annual appropriation of $10,000, an amount which dropped to $8,000 in 1896. At about the same time, the state finally became concerned with local roads. In 1879, the legislature had confirmed the previous declaration that all section lines be dedicated to public roads 66-feet wide. To fund road work, a three mill tax was established. Little more of significance occurred, though, until 1895 when the State Board of Irrigation was created. Supervision of roads and bridges soon came under the Board's purview. The Governor served as president; other board members were the State Attorney General and the Commissioner of Public Lands and Buildings. The board appointed a secretary, a state engineer, and other assistants as needed. Most bridge work, however, continued to be initiated by counties and local governments.[51]

In 1904, there were 79,462 miles of roads in Nebraska, mostly along section lines. Quality of both construction and maintenance was uneven. Throughout most of the 1800s, the situation was a concern, but not critical, since roads and bridges were intended for the slow-paced horse. Traffic was mostly local, with cross-country travel primarily via rail. Bridge safety became an issue, though, with the increasing weight of tractors and other farm machinery in the early 1900s. Lightweight trusses and stringers were ill-equipped to support the heavy equipment, and bridge failures became legion.

This prompted the 1905 legislature to direct the state engineer "to prepare plans and specifications, strain sheets and estimates of cost of any bridges which the county proposes to build" costing over $200. An extra $3,000 was appropriated to the Board of Irrigation to cover the cost of this extra work. In the following year, the state engineer reported that "this has added a large amount of work to this office... A set of standard plans has been prepared covering nearly all of the styles of bridges which may be requested." This pioneering set of standard plans appears to have been little used, however, since state help was only to be provided at the request of a county and "very few of the counties have taken advantage of this law." The *Biennial Report* of the state engineer for the years 1905-1906 includes photographs of a four-panel, pin-connected Pratt pony truss and a five-panel, pin-connected Pratt through truss, both in Madison County, and the 1907-1908 *Biennial Report* contains photographs of a 90-foot, six-panel, pin-connected Pratt through truss in Saline County and a 40-foot, three-panel Warren pony truss in Colfax County, all presumably illustrating the new state plans. This appears to be the only time that the state offered Warren truss plans until the 1920s. Occasionally, counties would petition the state engineer to prepare plans for specific bridges, as was the case with the Sargent Bridge (**CU00-73**), a double-span Pratt through truss built by the Custer County Board in 1908. Although the bridge is no longer a public thoroughfare, it remains on its original Middle Loup River site just south of Sargent.[52]

The automobile, though it aroused much interest, was still a novelty in the first years of the 20th century. A reportedly true incident illustrates early reaction to motor cars:

> A gentlemen [sic] traveling across Nebraska in 1903 with his bulldog named Bud, so startled a farmer that the poor fellow leaped from his haywagon and hid underneath. The sight of both driver and dog wearing goggles in an open-top vehicle speeding across the plains must have been a frightening apparition.[53]

By 1905, however, some began to sense that the automobile was here to stay, and that provision must be made for it. In that year, the Nebraska legislature set a precedent by requiring annual motor vehicle registration, setting the fee at one dollar. A total of 517 vehicles signed up the first year; a decade later the number jumped to 59,140, and to 233,000 by 1920.[54]

In response to the increasing importance of the state's fledgling road system, the Board's name was lengthened to the "State Board of Irrigation, Highways, and Drainage" in 1911. Two years later, an independent state highway department was established by the legislature. Another 1911 legislative landmark was the creation of the State Aid Bridge Fund, financed by a tax of one-fifth of one mill on the assessed value of property in the state. The amount collected was about $85,000 in 1911 and $90,000 in 1912. The fund provided a fifty percent state subsidy for county bridges over streams 175 feet or more wide. (In 1921, the minimum stream width was decreased to 100 feet.) Money was dispensed on a first-come first-served basis. Design and construction of State Aid bridges was jointly supervised by the county and the state. The law was revised in 1915 to allow funds to be used for the purchase and relocation of existing bridges, as well as for new construction. With the lure of money easing traditional county mistrust of state interference in local affairs, enthusiasm for the program was overwhelming. Only a year after the program's initiation, the state engineer wrote that "this law has done more than any other to stimulate the interest of counties in the building of permanent bridges, and sets an excellent example of the form of bridge construction in this State." The legislature's last appropriation to the fund was in 1933; the fund was closed out in 1936. During the fund's life, a total of 97 bridges at 80 locations were built or purchased. These bridges included most designs popular during the period, from steel trusses and girders to transverse joist girder spans and concrete arches. A majority were along the Platte and its north and south branches.[55]

In 1911, at the same time that the State Aid Bridge Fund was created, the legislature mandated that all bridges sustain a minimum twenty-ton load:

> The necessity for this is shown by the fact that each year there are a number of bridges, which fail under the twenty-ton traction loading, and these failures are invariably accompanied by injuries to the men in charge of the traction engine and not infrequently lives have been lost.

Unfortunately, the state engineer noted, "the enactment of this law rendered valueless all plans which had been prepared previous to 1911 in this office, none of them being designed to carry a twenty ton load." The office rushed to update plans, and by mid-1912 could report that "a standard set of plans, together with a number of special designs, have been prepared to meet the requirements of different counties during the past two years. Several counties have ordered sets." The report added that "this law should be amended so as to compel the counties to obtain all plans for bridges from this office." In addition to providing plans, the state office inspected county bridges at the request of county boards. Counties had to pay actual travel costs for the inspectors, but the service was otherwise free of charge.[56] While 36 counties used state plans for their annual bridge contract letting in 1914, response was decidedly less eager than it had been for State Aid bridge money. The state engineer's report for 1914 discussed reasons for the resistance, and explained why opposition was imprudent:

> There has been considerable criticism of the twenty ton carrying capacity law in our state and also that the steel bridges built upon state plans cost a great deal in excess of steel bridges formerly built by the counties... One reason why the steel bridges built under the state plans have cost more is because of the different class of work required which, under the state specifications, requires a better class and grade of shop work and a better grade of erection work in the field and the riveting of all field connections instead of bolting them as has been the practice heretofore. Another reason for the added cost is the fact that many counties in our state did not use a complete set of steel stringers in the floor system but used a majority of wooden stringers. On all state plans steel stringers are specified and required.

The same report, however, chronicled some progress: "Roadwork over the state has wonderfully improved during the past two years by reason of the County Boards of the different counties taking a greater interest in the roads." The state engineer had another reason to be happy: the 1913 state legislature had granted his wish that counties be required to adopt state standard plans for bridge construction. By this time the office had prepared "a complete standard set amounting in all to about 250 highway bridge plans." Superstructure plans included both wood and I-beam bridges spanning 12 to 32 feet with 14-, 16- or 18-foot roadways; steel girder bridges 30- to 40-feet long with 14- or 16-foot wide roadways; riveted and pin-connected pony trusses from 35 to 100 feet; riveted through trusses from 90 to 160 feet; and pin-connected through trusses from 90 to 304 feet. Most truss designs were available with either wood or concrete floors; all had 16-foot wide roadways. Steel pile and tubular pier foundations were also included, as well as standard contract forms.[57]

At the same time, the federal government was slowly taking some responsibility for road improvement. Congress passed the Post Office Appropriation Act in 1912, dedicating $500,000 toward construction of rural roads to facilitate mail delivery. State and local governments had to match two dollars for every dollar of federal funds received. Seventeen states took advantage of the opportunity, resulting in 425 miles of improved roads. This, however, was a very small step in the right direction.[58]

Despite government advances, private citizens became frustrated at the slow pace of progress and began organizing trail associations and "Good Road" clubs. One of the most important to Nebraska was the Lincoln Highway Association, founded in 1912 by Carl Graham Fisher, an Indiana real estate developer who had built the Indianapolis Speedway several years before. Fisher claimed that "the highways of America are built chiefly of politics, whereas the proper material is crushed rock or concrete." He proposed a road stretching from Jersey City, New Jersey, to San Francisco, named in honor of the nation's sixteenth president. The highway, described as "the shortest, most practical route connecting the two coasts, through the heart of the Union," was the country's first transcontinental automobile road. The section through Nebraska, which was completed in the early 1920s, originally passed through Omaha and proceeded west through the state. It was later designated U.S. Highway 30, and its eastern entrance to Nebraska rerouted north through Blair. Paving of a section west of North Platte in 1935 made it North America's first transcontinental paved road. Nebraska was also included in two other important early 20th century routes: the OLD Highway (Omaha-Lincoln-Denver), and the Meridian Highway. The latter, which roughly traced the Sixth Meridian from Winnipeg to the Gulf of Mexico, was conceived in 1911 by the world's first international highway organization.[59] Private efforts could only go so far, however, and both federal and state governments were soon to make a major commitment to developing the modern highway system.

VII. Cast in Concrete: Bridges of the Early 20th Century

By the second decade of the 20th century, concrete had gained favor as a bridge material. The 1912-1914 *Biennial Report* noted that the state had standard concrete plans for:

> small arch culverts, box culverts, slab bridges from eight to twenty foot spans by two foot intervals; girder bridges from twenty to forty foot spans, by five foot intervals; and arch bridges from ten to fifty foot spans by five foot intervals. The concrete arches also have several different rises given for the same length of span.

The report added that "this is the first attempt at standardizing concrete plans, specially of the arch type that has been made." Standard bidding blanks were modified to allow county boards to assess the cost of concrete in a way comparable to other bridge types. The state engineer felt that this sort of comparison would result in more concrete bridges being erected:

> The idea has always prevailed for some reason that to build a concrete bridge took a large amount of money, greatly in excess of a steel bridge. This is misleading and is not the fact. Under the twenty ton loading law as it now exists, the difference between a permanent steel bridge and a permanent concrete bridge is not so very great, and the use of concrete is becoming more popular.

He continued, however, that "one point must always be born in mind, and that is that a poor concrete job is worse than a poor steel job, and care should be taken in doing concrete bridge work to secure the best materials and properly experienced labor for the construction of the same."[60]

Concrete, used since ancient times, consists of two parts: binder, i.e. cement, and filler, which for road and bridge work is usually crushed rock, sand or gravel. Cement, essentially calcium oxide, is usually created by burning finely broken limestone. The resulting product is then mixed with water to form cement, which is either soluble in water (non-hydraulic) or, with the addition of silica and alumina, impervious to water (hydraulic). Obviously, only hydraulic cement was appropriate for use in road and bridge work. If the silica and alumina occurred naturally in the limestone, "natural" cement was created. While sometimes employed for bridge building, natural cement tended to be unpredictable. It was supplanted in the United States in the 1880s by Portland cement, in which silica and alumina were artificially introduced to achieve consistent quality. Quality control continued to be a problem until several decades into the 20th century when aggregate was more carefully selected and washed. Ascertaining correct proportions of water, cement, and aggregate was more of an art than a science, and mistakes led to structural failures. In 1874, metal reinforcing was introduced to compensate for monolithic concrete's lack of tensile strength. By the early 1890s, this technology was being applied to bridge construction. A number of patented reinforcement systems have been developed since that time. The type chosen for a structure often affects its appearance as well as its strength.[61]

Although all metal and much lumber had to be imported to supply Nebraska's bridge needs, the state was abundantly stocked with raw materials for cement. One historian mentioned that "in pioneer days, many sod houses of Nebraska were plastered inside and out with a native magnesia cement." The area's first recorded quarrying of limestone was undertaken northeast of Omaha in 1819 by army troops under the direction of Major Stephen Long. Later in the 19th century, a number of lime kilns were operated in the southeastern part of the state.[62]

Railroads were the first to utilize concrete on a large scale for bridge construction, adapting it first for substructure components, then for actual bridge structures. Nebraska's Department of Public Works acknowledged this precedent in a 1919 publication:

> **Highway and Bridge engineers in many of the Western states following the lead of the railroad companies, have resorted to concrete masonry construction in bridge building, the chief reason being that concrete bridges when properly built, will remain as permanent structures for an indefinite period of time.**

All concrete for bridge and pier construction was probably imported from out of state until the early 20th century. In 1915, apparently spurred on by the state's enthusiasm for concrete bridges, a cement plant opened (or perhaps reopened) at Superior. It was not until 1929, however, that the state's second cement plant opened in Louisville, indicating that other sources were apparently still supplying a large portion of the state's significant demand. In the mid-1910s, the state engineer had mused that "one difficulty to overcome in the development of the cement industry in Nebraska will be the competition of large plants located in nearby states... Most of these plants have cheap fuel and good cement material."[63]

Regardless of where the cement originated, a concrete bridge building boom soon ensued. A 1919 highway department article explained that:

> **in making a decision between an arch and a beam design there are several determining factors. Cost is usually the first consideration... The chief determinant however is the height of the grade above high water. Beam bridges are not suitable for carrying high fills while arch bridges can be built to support any height of fill. Arches are especially adapted for use in deep ravines, can[y]ons and other places where a high fill must be supported.**

The article added that:

> **simple slabs are economical for spans under 12 feet, beam bridges supported on stringers or longitudinal beams from 12 to 25 feet and slab bridges with two heavy side beams carrying lighter cross beams supporting the floor slab, 25 to 35 feet. Beam bridges have been built up to 70 feet in length but they are not generally economical as arch bridges are cheaper... On very long bridges, where the grade is high above the river bed, the cost of the piers largely determines the cost of the bridge. Under these conditions it is cheaper to build long span steel bridges and to renew them from time to time.**[64]

Aesthetics became an important consideration in bridge selection in the 1910s. Designers were at first unsure how to treat concrete, and either textured it to imitate stone or left it a plain, monolithic hulk. After becoming more accustomed to the material, however, designers became more creative. Waddell insisted that "there is little excuse for building an ugly concrete bridge." Most people, though, were accustomed to the tracery of truss bridges. While immediately appreciating the arch form in concrete, the public was initially unimpressed by the sparse look of girder and beam spans. A contemporary wrote that "frequent objection has been made to the use of them for the reason that they are not susceptible to artistic treatment." While the writer maintained that "this objection no longer exists," the records show that if there had been a popularity contest for bridges in the early 20th century, concrete arches would have won by a long shot.[65]

The 1910s saw concrete used for a number of major river crossings, often replacing the trestles, combination spans, and iron trusses from the last decades of the 19th century. A series of State Aid concrete girders were built along the Platte and North Platte, including structures at Overton, Lexington, Bridgeport, Bayard and McGrew, but the more graceful arch was soon the style of choice. Multiple-arch bridges were built over the Niobrara River near Carns in 1912 (**RO00-72**) and over the Republican River near Cambridge in 1914 (**FN00-98**), and at Superior a year later, perhaps in honor of the new cement plant there. A string of concrete arch bridges were built in Scotts Bluff County in 1918-1919 at Henry (**SF00-40**), Morrill, Mitchell, Scottsbluff and Minatare. The highway department described the modular procedure used to build the Scotts Bluff County bridges:

> **A one-half yard mixer plant is erected and a trestle is built longitudinally with the bridge. This trestle has a track on top for the concrete cars and a lower track to carry stripped forms and lumber ahead. The upper track is utilized for the same purpose and a short boom is attatched [sic] to the concrete car and the panel forms on spandrel walls are quickly unbolted and moved ahead.**[66]

Further downstream was the 14-span Birdwood Bridge north of Sutherland (**LN00-32**). Other concrete arch bridges were scattered along the Platte at Kearney, Shelton, Grand Island and Central City (**MK00-5**). Concrete arches also bridged the Republican at Bartley in 1918. The latter, however, was to be the undoing of this style: it collapsed within a few years of its construction under pressure from high water. The last major concrete arch bridge was completed south of North Platte in 1924, and a report at that time noted that "the present tendency of design is toward steel truss or transverse joist type with concrete floor and foundations in place of the heavier multiple concrete arches."[67]

While smaller truss bridges had already achieved the appearance - if not the qualitative substance - of standardization, larger structures prior to concrete designs had generally been customized to the particular situation at each crossing and each had, thus, a relatively unique appearance. Concrete girders and arches, however, were smaller units of 33 to 36 feet and 50 to 85 feet, respectively, which could be strung together to fit the necessary span. Rhythm of the spans, design of the balustrades, and any ornamentation could look identical from Central City to Henry. These bridges thus represent the first true standardization of major river bridges in the state.

More modest concrete bridges, as well as concrete arch and box culverts, also appeared around the state during the 1910s. Two single-span bridges in Webster County built in 1911 display local forays into concrete arch construction. Their guardrail design - pipe rails supported by pipe posts set into a low concrete parapet - is not typical for the time, and mark them as non-standard plans. In fact, Webster County commissioners rejected the state's plans in 1910 and again in 1913, declaring "that they were not in harmony with the board's ideas as to what they want." Despite this opposition, the state engineer finally won over the commissioners and they adopted state plans later that year.[68] The most aesthetically successful of these single-span structures is a small bridge on the outskirts of Nebraska City (**OT00-85**). Built in 1912, it features cast concrete balusters enframed by handsomely proportioned concrete bulkheads.

A surprising number of small, state standard plan, concrete bridges survive from this period, a tribute to the persuasiveness and unflagging energy of the state engineers and their staff. The 1915-1916 *Biennial Report* shows a small concrete arch bridge in Fillmore County, a 16-foot concrete slab bridge in Clay County and an arch culvert in Seward County. Clay and Fillmore counties especially called on the concrete arch for a number of bridges in the early decades of the 20th century, and these neighboring counties harbor the state's largest surviving collection of this type. Other well-preserved concrete arches are the Stewart Bridge (**NU00-729**), a 46-foot span built over Big Sandy Creek in Nuckolls County in 1915, and the Deering Bridge (**CY00-11**), a 50-foot span in Clay County. All have monolithic cast railings with recessed panels.[69]

The interest in small concrete bridges appears to have been concentrated in the state's southeast corner, a logical development considering that Superior was the probable source of the cement. There were, of course, exceptions, such as the 20-foot reinforced concrete slab bridge in Hitchcock County (**HK00-78**), two miles east of Stratton. Built in 1908 by the otherwise obscure Ideal Cement Company, this modest structure is today Nebraska's oldest concrete highway bridge.[70]

VIII. The Federal Aid Highway Act

President Woodrow Wilson signed the Federal Aid Highway Act on July 11, 1916, ushering in a new level of federal government commitment to road building, which swept the states along in its wake. Part of the impetus was from the postal service, which had difficulty delivering mail in many rural areas because of the poor condition of roadways. Business leaders also promoted the legislation, citing the need for more reliable roads to get farm commodities to market. The legislation's goal was to develop an interconnected system of well-built and well-maintained roads throughout the country. Seventy-five million dollars was initially available to states, apportioned by a ratio based on area, population and miles of rural postal roads. The allotment had to be matched dollar for dollar by the states, and could only be used on projects approved by the U.S. Bureau of Roads. Expenditures could not exceed $10,000 per mile, not including bridge costs. The latter were paid by counties, sometimes with state assistance. Funds could only be used on rural roads, or on roads in communities with under 2,500 inhabitants.[71]

Nebraska's share of the initial appropriation was about $1.6 million, which it matched by placing a mill levy on real estate. Although the state received an additional $4.27 million in 1919, for most years during the 1920s its annual appropriation remained around $1.6 million. Because of the distribution ratio, this funding far exceeded what Nebraska would have obtained on a strictly per capita basis. In 1922, a state publication explained that:

> **Nebraska receives in Federal Aid about 7-1/2 times more in dollars than she pays into the fund, and New York, for instance, pays into the fund 10 times more than she receives from Federal Aid... It is the only instance within our knowledge where we can make New York pay for some of our improvements.[72]**

In order to qualify for federal money, states had to designate roads eligible to receive federal aid. Nebraska complied. As soon as the routes were decided, however, some counties concluded that their responsibility for these roads had ended and quit maintaining them. Even roads which had been improved with federal aid were deteriorating within months of construction, leading the Bureau of Roads to threaten to withhold further funds unless Nebraska passed legislation providing for adequate maintenance. To be fair, maintenance was not an easy task in the vast state. There were not only the ravages of weather and vehicular traffic to worry about: a report complained that in the sand hills region "large herds of cattle tramping around on the roads do considerable damage."[73]

In addition to delineating federal highways, Nebraska designated a state highway system in 1919, consisting of about 5,000 miles of roads organized into 88 routes. This network, which essentially went from county seat to county seat, was intended to connect farm and market. It was supplemented by a county road system authorized at the same time.[74]

Also in 1919, the state government underwent major reorganization. The new Civil Administrative Code Bill abolished the Board of Irrigation, Highways and Drainage, replacing it with the Department of Public Works. Within this new department was the Bureau of Roads and Bridges with three subdivisions: the Division of Construction, the Division of Road Equipment, and the Division of Maps and Plans. The Division of Maps and Plans was responsible for "preparation of Federal Aid Road plans, State Standard Bridge plans, State Aid Bridge plans, State Institution Paving plans, Special Bridge and Culvert plans for Federal Aid Roads, and special bridge plans for the various counties." In the 1919-1920 biennium, for example, the division revised 48 standard bridge plans, checked 52 detailed shop drawings, completed 11 new standard plans and 96 calculations for these plans, finished plans for construction of 7 State Aid bridges and for repair of an additional 12, developed plans for 54 special bridges and culverts for Federal Aid roads and 25 special county bridges, checked 27 special county bridge plans, and revised one set of bridge specifications.[75]

As is evident in this tally, state standard plans were reworked again in 1919 "on account of the evolution of traffic," this time under the watchful eye of the federal Bureau of Roads. Roadways for all 20-ton capacity bridges were widened to 20 feet, while a 16-foot roadway was still considered adequate for 15-ton bridges. As time allowed, however, all old standard plans were being revised to include 16-, 18- and 20-foot widths to "eliminate many extras on bridge contracts now required to cover roadways which are not shown on Standard Plans." Detailing was improved, and "provision is also being made for the addition of bituminous wearing surface to a depth of two inches at any further date when it may be desired." The plans were revised yet again in 1923. Among other things, the low-hanging bottom chord was eliminated on 20-ton riveted trusses and detailing of shoes and panel points was simplified. Standard specifications, which had been introduced in 1917, were revised in 1920, using specifications from other states as reference. Although these had to be approved by the Bureau of Public Roads, the federal government did not allow any of its subsidies to be used for bridge construction until a policy change in 1923.[76]

All of this work was completed by a department that was hampered by understaffing. In a 1919 report, the highway department complained that they had been:

> handicapped during the present year by a shortage of engineers, for making preliminary surveys. This condition has been caused by the great number of engineers who are still in the army service, and partly by the universal demand caused by the necessary expansion in the Department necessitated by recent road legislation.[77]

In 1923, a division specifically for bridge design was created in the Department of Public Works. Three years later, the state took over all responsibility for letting contracts for state and federally funded projects, eliminating the past practice of county participation. To streamline the procedure, the state followed the lead of the counties in consolidating contract lettings:

> At one letting which was held April 27th, 28th and 29th, 1927, 115 bidders submitted proposals for work on 142 different projects and contracts were awarded for 343.9 miles of grading work with the construction of incidental culverts and guard rail, for 848.9 miles of gravel surfacing and for the construction of 55 bridges. The amounts of the contracts awarded at that time totaled more than $3,488,000.[78]

With the growing number of projects came more sophisticated oversight. Before contracts were let, a representative from the department inspected the proposed site. Upon approval of the location, field engineers conducted a more detailed analysis of the general drainage area and of the specific soil and geological conditions. The bridge division then weighed field information, traffic demands, and economic considerations to select a bridge type. Bridge design was a laborious task, involving calculations for stresses, determination of necessary structural components, and preparation of detailed drawings.

Because of the possibility of error and its potentially grave consequences, special "checkers" repeated the process to insure a correct plan. After the contract was let, a field engineer supervised the contractor to insure that work was done according to plan. Samples of construction materials were tested by the division's lab, established at the engineering department of the University of Nebraska in the early 1920s to analyze materials used in highway projects receiving federal or state aid. The completed project was inspected by appropriate officials from the Department of Public Works and, if accepted, final payment was made.[79]

Beginning January 1, 1926, the Department of Public Works also assumed responsibility for maintenance of the entire highway system, except sections in communities with populations over 1,400. These additional tasks severely strained the state's budget. Some balance was regained when county funds, as well as state funds, were permitted to match federal aid dollars.[80]

Nebraska and Florida were the only two states to adopt a "pay as you go" policy for road and bridge construction. While other states issued bonds to finance highway work, Nebraska stayed within the limits of money it could raise from property taxes and from user fees, such as motor vehicle registration. The state's first gasoline tax, two cents per gallon, came in 1925. In 1929, it was raised to four cents. In 1926, the state engineer wrote that "even now, when more money is being spent than in previous years, the yearly expenditure is but one-third of that on the trunk highway system of Minnesota, and one-fifth of that spent annually in Missouri, and a little over one-half of what is spent in Iowa and Kansas." A 1928 report noted that "the expenditures of state funds each year in many middle western states amounts to as much as the total expenditures to date, or for the last ten years of state funds for construction in Nebraska."[81]

The state's parsimony forced creativity in the highway department, and Nebraska gained national - even international - attention for its innovations. The state pioneered economical techniques in dirt highway construction. Experiments were also conducted with oil coating, gravel, and, in the sand hills, hay. An official of the Argentine Highways Department, one of many visitors seeking information about the state's highway construction methods, commented that "they get more roads for less money than any other state in the two Americas." As late as 1940, the head of Nebraska's highway department asserted:

> **I believe there is no doubt but that Nebraska has been taking a leading part in the development of low-cost pavements... One might say that the low-cost pavements have been "custom-built" in Nebraska, after careful investigation of soil, moisture, drainage, and other conditions that enter into the problem.**

At the same time, he had to admit that it was only within the past five years that sixty percent of the state highway system had been paved.[82]

Significant expenditures for some things were, however, unavoidable. As the number of roads and vehicles increased, accidents at railroad crossings became a more common occurrence. As of 1917, there were about 11,300 grade crossings, an average of one every thirteen miles of highway. Only about five percent had any sort of protection, and those were mostly in densely populated areas such as Omaha and Lincoln. Among the grade separations claimed by Lincoln was the nineteen span, 900-foot long, deck plate girder North Tenth Street Viaduct (**LC13-367**) built in 1910. Early rural grade separations were rare. Elimination of highway-railroad crossings became a major emphasis in road improvement in the 1920s. While some crossings could be avoided by realigning roadways, others required construction of viaducts and subways.[83]

IX. Bridges of the 1920s

In addition to innovations in road construction, Nebraska created and popularized a new bridge type, the transverse joist girder. Robert Z. Drake, of H-beam pile and Standard Bridge Company fame, is credited with inventing this design as well as the multiple punch necessary for its manufacture. The first bridge of this type appeared in the early 20th century. In the late 1910s, transverse joist girder bridges were added to the state's set of standardized plans. At about that time, the style was chosen to replace the ill-fated concrete arch bridge over the Republican River at Barley, and it appeared over the Platte at Brady, Cozad and Yutan. More followed at Hershey (**LN00-31**), Boelus (**HW00-63**), Grand Rapids (**HT00-261**), North Platte, Gothenburg, Gibbon, Duncan and Plattsmouth. Spans were typically fifty to sixty feet for major river bridges, with roadways ranging from 16 to 20 feet in width. By 1927, there were more than 1,000 transverse joist girder bridges in the state.[84]

An engineer in the 1920s praised the transverse joist girder design as "one of the simplest types of permanent bridges manufactured." As the name implies, joists run perpendicular to the roadway, fastened at each end to the web of I-beam girders. Used in both through-girder and deck-girder configuration, the design was relatively inexpensive because the components could be easily standardized, minimizing custom design work for fabrication. Erection was quick, using a small labor force and requiring no expensive falsework.[85]

As with every bridge style, the transverse joist girder had some drawbacks. Economics of construction dictated a maximum width of twenty feet. Widening the bridges at a later date was difficult and expensive. Ever increasing traffic volume demanded wider roadways, sealing the fate of the transverse joist girder bridge; their construction virtually ceased by the late 1920s.[86]

In the meantime, trusses continued to be chosen for longer spans when there was a need to minimize substructure. A string of double-deck, riveted, Pratt through truss spans, designed for pedestrian and vehicular traffic on the upper level with rail tracks below, carried the Meridian Highway from Nebraska to Yankton, South Dakota (**CD00-256**). Built between 1920 and 1924 and costing over $1 million, construction was arranged and financed by local business interests. The superstructure was fabricated by the American Bridge Company and erected by Kelly Atkinson Company; the substructure was built by Missouri Valley Bridge and Iron Company. The bridge, which was designed by the prominent Kansas City engineering firm Harrington, Howard and Ash, included a patented Waddell and Harrington vertical lift span to accommodate Missouri River navigation. This popular movable bridge design was named after its developers: John Harrington, a principal of the Kansas City firm, and J.A.L. Waddell, his former business partner.[87]

Harrington, Howard and Ash was also responsible for the design of the Abraham Lincoln Memorial Bridge at Blair (**WN00-83**), with Sverdrup and Parcel of St. Louis serving as consulting engineers. This structure, too, was promoted by a local group, which formed the Nebraska-Iowa Bridge Corporation. When completed in 1929, the toll bridge became the official route of the Lincoln Highway, saving drivers 28 miles and allowing them to avoid the inevitable delays of downtown Omaha traffic. Construction was overseen by the Woods Brothers Construction Company of Lincoln, a major contracting firm which had already been involved with development of five Mississippi River bridges. The 1,340-foot superstructure consisted of three massive Pennsylvania truss spans, totalling 1,000 feet in length, plus deck truss and steel stringer approach spans. It was built by the Wisconsin Bridge and Iron Company, Milwaukee, with the Kansas City Bridge Company responsible for the substructure.[88]

Sverdrup and Parcel teamed up again with the Woods Brothers in 1930 at Nebraska City to build the Waubonsie Bridge, named in honor of a Pottawattami chieftain. The Waubonsie Bridge Company, the toll bridge's promoter, was actually a subsidiary of the Woods Brothers, formed by the company and a group of Nebraska City businessmen. The Kansas City Bridge Company was responsible for erection of the structure, which cost slightly under $1 million. Featuring an early use of the principle of continuity, the through truss superstructure incorporated silicon steel members, which were stronger and lighter than the more commonly used carbon steel. Continuous trusses were also employed at a contemporary toll bridge just upstream at Plattsmouth (**CC00-215**), which was designed, fabricated and erected by the Omaha Steel Works.[89]

A contemporary engineer found the Waubonsie's substructure noteworthy as well: "The supporting piers are very distinctive in a modern or skyscraper design, employing set-backs at various elevations, as seen in modern skyscrapers." He also claimed that it was "the first bridge to be completed with a complete system of electric navigation lights, with a standby kerosene system." Conduits in the curbs concealed wiring.[90]

For bridges across other waterways, the tried and true Pratt pony truss was still often the choice for large state and federally aided bridges in the 1920s. Instead of light members and pin connections, these trusses were made from heavy-duty components riveted in place. Improved truss designs had higher curbs, stronger guardrails, and 22-foot or wider roadways. Floor beams no longer projected below bottom chords but were flush with them. Series of from seven to ten, 80- to 100-foot, five-panel Pratt pony trusses crossed the North Platte at Broadwater (1924-25, **MO00-170**), Lisco (1928, **GD00-118**), and Lewellen (1927, **GD00-119**).[91] The tendency toward heavier construction was visible on the county level, too, thanks to almost universal use of standard state plans. While pinned connections continued to appear on some through trusses with large spans, rigid connections were more and more prevalent. Almost all pony trusses were riveted by the mid-1920s.

Heavier trusses offered longer life and greater load capacity over lengthier spans, but timber stringer and trestle bridges were a more economical choice for short spans on little traveled roads. For small bridges "where traffic is dense and stream characteristics are well known," 25- to 32-foot I-beam spans were often used. Both timber and I-beam spans were usually built with a 24-foot roadway by the late 1920s.[92]

Timber was decidedly out of favor, however, for bridges on major routes. Monthly reports from the Department of Public Works in 1919 reported case after case where old wooden bridges were being replaced by concrete structures, including four on the Lincoln-Crete-Dorchester Highway and two on the Cornhusker Highway north of Havelock. In Lancaster County, a number of new bridges were "to be constructed of concrete with twenty-four foot roadways and the road grade will be twenty-six feet wide on all of them." On a smaller scale, concrete culvert pipe was produced by fifteen plants in the state by 1931. Counties also made their own culverts, keeping road crews gainfully employed during the long winter months. As early as 1916, a state report described this "cottage" industry, and also discussed culverts of a size which required construction at the site. Forms were of wood or metal. The same technique and grade of concrete was also used for bridge wingwalls and abutments.[93]

X. The Great Depression: A Boon for Bridges

While the Great Depression devastated much of the United States, the road system benefitted. The unemployed needed jobs, and highway construction produced them in abundance. In 1933, Nebraska received $7,828,961 from the Federal Emergency Relief and Construction Act of July 1932, not more than fifty percent of which was to be used on the Federal Aid highway system and not less than twenty-five percent to be directed to extensions of the Federal Aid highway system into and through municipalities. While originally the act required states to match funds, that provision was later repealed, setting a precedent for 100-percent federal highway subsidies. The act was also a 180-degree shift from previous restrictions limiting use of appropriations to the federal aid system, with no allowance for urban highway construction. Not only did the cities need the improvements, but, in addition, most of the unemployed were concentrated in urban areas. Subsequent legislation encouraged grade separations, bridge widenings, and the development of a feeder road network. By 1934, an average of 18,600 Nebraskans a month were employed on federal and state highway work. The majority of these were laborers, but the work force also included "many engineers who had been thrown out of employment by the retrenchment policies of the railroads, architectural and municipal offices and other employers of engineers." The regular pre-Depression federal aid program, which required state matching funds, was reinstated in July 1935, but thereafter funds could be used for urban as well as rural federal highways.[94]

Since employment was as important a goal as construction, federal funds during this period were expended with some unusual stipulations, in effect turning the clock back to the days before many labor saving machines were available: "cement and reinforcing steel shall be unloaded by hand labor methods... Finishing of structural concrete surfaces shall be done by hand rubbing or other labor methods... Carpenter work and form work shall be done by hand labor methods and the use of mechanical saws will not be permitted at the bridge site... All painting shall be done without the use of mechanical equipment." Civil Works Administration projects permitted not more than ten percent of funds to be used for equipment or materials, so the state was forced to supply these on most projects. By the mid-1930s, the Federal Emergency Relief Administration corrected this overzealous rule and allowed greater expenditure for materials.[95]

The Department of Public Works, renamed the "Department of Roads and Irrigation" in 1933, gained hands-on experience with the intricacies of bridge construction in the process of managing federal relief projects. While the state had occasionally directed prison labor for road construction in previous decades, it was not until 1935-1936 that the department became so frustrated by high bids for bridges at McCook and Franklin that it became its own general contractor, hiring and supervising labor directly.[96] While these federal works projects greatly spurred bridge construction in Nebraska in the 1930s, other factors were influential as well. Woes brought on by the Depression were compounded by weather extremes that first dried, then drowned, the state. The drought phase led to widespread interest in irrigation. The resulting projects created canals which had to be bridged. Then in May and June 1935, the sky drenched southern Nebraska leading to disaster in the Republican River valley, where 341 miles of highway, 307 bridges and 1,007 buildings were destroyed. The state received $150,000 outright from the Federal Emergency Relief Administration and an additional $276,000 Emergency Flood Relief appropriation, which had to be matched by state dollars, for materials and labor to build and reinforce county bridges damaged by the flooding.[97]

The rural electrification movement also stimulated bridge building. The 33-mile Loup River Power District canal, completed in 1936, necessitated construction of 24 farm drainage bridges, 24 county bridges, two railroad bridges, two city street bridges, and three state highway bridges.[98] Another change during this decade was the movement toward professionalism in the engineering field. The department had experienced some difficulty with staffing in the mid-1930s: "There was an unusually high percentage of turnover in personnel, due to resignations of many trained designers and inspectors, who obtained employment with various other Public Works projects, both within this State and elsewhere." Apparently, however, this problem had eased by 1937 when legislation became effective requiring many state highway department employees, from heads of divisions and engineers down to the project engineer level, to be licensed as professional engineers. The State Board of Examiners for Professional Engineers and Architects was created to establish criteria and to enforce compliance. By the end of 1938, 184 state engineers had qualified, and an additional 35 were at some stage in the application process. Instead of being jacks of all trades, as had been necessary in earlier days, engineers became more specialized. The department found that "a higher degree of efficiency has been obtained and better work has been produced by those engineers who have been trained principally in the preparation of plans and are not called upon to divide their time between office and field work." During the same period the highway department was once again reorganized, and the Division of Maps and Plans and the Division of Bridge Design were consolidated under a new Division of Design.[99]

XI. Bridges of the 1930s

The 1930s saw significant changes in both superstructure and substructure design. The days of the ubiquitous H-beam pile were over. Battered steel pile abutments were introduced in the early 1930s. These could be driven into frozen ground, permitting year-round construction. Later in the decade, the department experimented with concrete slope protection, such as that covering the banks under the Verdigres Creek Bridge in Knox County. Bent design underwent a transformation as well. Twelve of the bridges built during the 1935-1936 biennium were supported by open steel pile bents, a simplification of earlier concrete-encased bent designs. The state engineer explained that the change was "due to a more lenient attitude in the requirements of design on the secondary highway systems" on the part of federal and state agencies. On the other hand, the department took pride in producing attractive substructures where appropriate. For example, the Beatrice Viaduct, built in 1935-1936, was "notable... for the architectural treatment of the columns supporting the superstructure."[100]

A new bridge design conceived by the department in the early 1930s called for yet another substructure. Thirty percent of the 281 bridges contracted by the state in 1931-1932 and 38 percent of the 242 bridges in the following biennium were "concrete slab bridges with substructure of creosoted timber piles capped with reinforced concrete beams." While the concrete slab was initially used instead of box culverts, the department soon concluded "that the concrete slabs may be used to just as good an advantage in certain locations where steel spans had to be used previous to the advent of the concrete slab type." When culverts were called for, preference was for concrete, multiple box designs.[101] Concrete slab bridges and box culverts were noted for utility and economy, and were excellent choices for rural settings where those traits were of primary importance. In urban areas, however, aesthetics were an issue. A provision requiring that at least twenty-five percent of some federal relief funds be directed to urban construction had, according to a department report:

> **its effect on certain bridges and grade separations and is the cause of certain in[n]ovations with respect to bridge design. It was required that such bridges should be given architectural treatment to the end that their appearance would be in harmony with the general scheme of beautification attempted by the average mid western city.[102]**

These aesthetic concerns led to widespread use of the rigid frame bridge, a monolithic, flat-arch style of reinforced concrete or steel with concrete facing. Developed by New York's Westchester County Park Commission in the early 1920s, the style was felt to be both picturesque and practical. It was used extensively for viaducts and subways, including structures at Hastings, Falls City, Auburn, Emerald and North Platte. To further ornament the arch of the Saddle Creek Subway (DO09:322-114) in Omaha, old stone curbing on Dodge Street that was being removed by a federal aid project was cleaned and cut by Civilian Works Administration workers and installed as facing. Nicely detailed concrete handrails and ornamental lamp posts decorated the West O Street rigid frame bridge in Lincoln. About 1937, the rigid frame design was called on for the state's first rural highway grade separations, cloverleaf intersections on Dodge Street and Center Street in Douglas County. The Hastings Subway (AD04-716) is further distinguished by the fact that the structure's steel frame was the first in Nebraska to be completely joined by electrical welding. This experiment was the result of the department's decision to send a staff designer to a renowned welding school in Cleveland.[103]

By the mid-1930s, the state engineer noted that "the steel-truss type of bridge is being used sparingly, due to the better adaptation of deck construction to the Nebraska terrain and stratigraphy." Girders for deck spans were basically large-scale I-beams, and the first bridges utilizing them were essentially simple stringer structures. Deck steel girder roadways were usually 22- to 24-feet wide by the late 1920s, and they could be easily widened if necessary. Typical span length increased during this period from fifty to sixty feet, although smaller lengths were also used.[104]

When steel mills increased the maximum girder web depth from 30 to 36 inches in 1928, feasible simple span length jumped from 62.5 to 75 feet. This, however, was not significantly longer than the typical transverse joist girder spans then in use. A major breakthrough came when it was discovered that much longer spans could be created using the principles of continuity and cantilevering. In the early 1930s, Nebraska experimented with continuous spans for bridges over 120 feet total length. Josef Sorkin, a bridge designer for Nebraska, published an article in *Engineering News-Record* explaining that:

> **the advantage of a continuous design over a simple-span design is purely that of economy, manifested in two principal ways: (1) The material is used more efficiently, and (2) the allowable stresses need not be reduced due to the relative shallowness of a beam in longer spans.**

Sorkin added that "complications in providing for the expansion and contraction of unduly long beams suggest that in multiple-span bridges groups of three continuous spans are desirable."[105]

Sorkin wrote an engineering thesis on cantilevering, a method which further expands the potential for span length. The department tried the technique on girders with the Chapman State Aid bridge in 1932, but the 64-foot span was not much of an advance over existing designs. With the 679-foot Loup River bridge north of Cairo, however, the department was far more daring. The 1933-1934 *Biennial Report* claimed that the "central span of 115 feet is the longest deck steel girder highway bridge span constructed of standard rolled beams, to be found in the United States." Others credited the span with being the longest of its type in the world at the time of construction. The department's report emphasized the significance of the accomplishment by reminding readers that "up to a recent date the maximum span length obtainable for girders was 60 to 65 feet although the average length most generally used was in multiples of 50-foot spans." Further development by the state resulted in efficient design and construction, displayed in the winter of 1934-1935 when the same plan was used for State Aid bridges at Brule and Roscoe (KH00-92), both completed within a few months.[106]

As usual, money played a role in the department's enthusiasm for cantilevered spans. The longer spans meant fewer piers, often resulting in significant cost savings. In addition, the design required relatively little maintenance. By 1932, the department pronounced that the deck steel girder was "now considered to represent one of the most permanent and adequate types of structure yet devised for this region." In addition, "while various other groups show a cheaper first cost it is believed that, owing to the long life and low maintenance cost of deck steel girders with concrete substructures, they will prove to have a lower annual cost over a long term of years." The straightforward girder bridge design shared the positive aspects of transverse joist girder bridges in that it was relatively inexpensive to fabricate and erect. Also, this type could easily be adapted to a skew, a distinct advantage since the department calculated that in the 1931-1932 biennium "21.6% of the jobs tabulated are either skewed or curved in plan."[107]

Occasionally, the department took an opportunity to consider factors other than economics. Sorkin and fellow engineer John G. Mason explained that "aesthetic treatment of Nebraska bridges is seldom economically justified due to the alluvial character of the streams - typically wide and shallow." Simple, undramatic designs were the most pragmatic for such waterways. However, when they were called upon to design the Bryan Bridge (**CE00-28**) over the steep-banked Niobrara near Valentine, Mason and Sorkin were convinced that "any structure of ordinary appearance would mar the natural beauty of the banks and immediate surroundings." As a result, "arched cantilever spans were adopted in spite of the slightly greater cost." The 290-foot deck truss structure, built in 1932, won the American Institute of Steel Construction's annual "Most Beautiful Bridge" award for its class.[108]

The continued demand for new bridges across the Missouri River during this decade provided financial rather than aesthetic challenges. Given the country's troubled economic situation, federal subsidies were needed to foster any construction. Citizens of Omaha discovered this in 1931, when the bonds that the city issued to finance construction of a bridge between south Omaha and Council Bluffs failed to find buyers. After President Roosevelt initiated his New Deal, an appeal to the Public Works Administration yielded a loan and 30-percent grant totalling $1,650,000. Ash, Howard, Needles and Tammen, successor to the Kansas City firm previously active in Missouri River bridge design, planned the 2,126-foot structure, which included a two span, 1,050-foot, silicon steel, continuous Warren truss (**DO09:97-1**). The bridge, which opened in January 1936, was built by the Kansas City Bridge Company.[109]

The same engineers were also responsible for the innovative design of the Brownville Bridge (**NH00-85**), built in 1939 with the assistance of a $311,580 PWA grant. The two span, 840-foot, continuous through truss rested on piers built without using traditional pneumatic construction. Instead, cylinders formed from interlocking steel sheet piles driven down to bedrock served both as bearing piles and as the cofferdam for pier work. This method, developed in 1937, avoided the high equipment and labor costs associated with pneumatic caissons.[110]

John Harrington, a former principal of Harrington, Howard and Ash, established a partnership with Frank Cortelyou, and the firm was hired to design and supervise construction of the Missouri River bridge at Rulo (**RH00-66**). The bridge was opened to traffic in 1939, funded by a PWA grant of $326,250 plus $435,000 worth of bonds. Three, 376-foot, Pennsylvania trusses crossed the main river channel, with both ends approached by five deck truss spans, each measuring about 100-feet. Streamlined set-backs in the concrete piers echoed architectural styles of the day.[111]

XII. Deprivations of War: The 1940s

The onset of World War II brought highway plans to an abrupt halt. Funds and most construction materials, especially steel, were diverted to the war effort. New concrete bridge designs were developed which compensated for the lack of reinforcement by calling for greater amounts of concrete. The use of additional concrete increased costs, but not as fast as prices skyrocketed for other materials in short supply. The maximum length of central spans of cantilevered concrete slab bridges that could be justified economically increased from 37.5 to 48.5 feet. Soon even concrete became hard to obtain, and the Department of Roads and Irrigation was forced to limit work to emergency construction and maintenance, or to use all-wood construction. An excellent example of this latter bridge type was the Brownson Viaduct (**CN00-30**), a 13-span timber stringer trestle built in 1942 to provide access to the Sioux Ordnance Plant in Cheyenne County. The state also helped the war department by loaning idle highway equipment, constructing auxiliary landing strips along highways, and developing roads leading to military installations. It was just as well that demands on the Department of Roads and Irrigation slowed during this period, because it faced staffing shortages. Many employees left for military service, while others were lured away by more lucrative jobs in the defense industry.[112]

As the war raged on, the department did what it could to prepare for post-war construction. Standardized plans were refined to be more easily adaptable to a variety of locations. New concrete slab plans, for example, covered bridges up to three spans, 40 to 120 feet in length, with straight orientation or having 15- and 30-degree skews. The department explained that "with the aid of this standard plan, a draftsman having a very limited knowledge of design will be able to prepare a plan for any particular bridge site, since all design computations involving stress analysis will be eliminated." Culvert plans were revised with the same goal. The department also, with encouragement from the federal government, planned a massive construction campaign for after the war, both to make up for lost time and to employ former military personnel.[113]

Although the department was prepared to let about $2 million in bridge and viaduct contracts when the war ended, it was frustrated by continued shortages, particularly of steel:

> **Up to the present time, more than a year after the cessation of hostilities, the material and equipment situation is more acute than at any time during the war. Due to this situation, it was impossible for the Department to carry on an extensive highway building program... Due to the steel situation it was apparent that no major bridges or viaducts could be constructed during 1946.**[114]

In some cases, construction simply could not be delayed. Douglas County began a 510-foot, cantilevered, deck plate-girder bridge near Elk River in 1944 to replace another structure washed away by floods on the Elkhorn River. At about the same time, Dodge County started a 435-foot, five-span, continuous girder bridge at Nickerson. The latter was significant as "the first structure to be constructed with Federal-aid funds where welding was permitted in main stress carrying members."

It was a pragmatic decision: use of welded connections was estimated to reduce the amount of steel required for the superstructure by twenty percent. Despite need and innovation, however, the projects were delayed. Late in 1945, the district engineer reported that "bridges over the Elkhorn at Nickerson and Elk City have been under construction for over a year, but due to shortage of materials neither structure has been completed."[115]

The state's construction program was further impeded by continued staffing troubles. The department promised to rehire employees who had gone off to war, but many failed to return "because of the fact that other fields have been able to offer more attractive positions from a remunerative standpoint." In response, the department set up its own engineer training program, in which 154 were enrolled in 1946.[116]

As in previous times of shortage, creativity was the order of the day. When a timber bridge over the Cedar River southeast of Belgrade washed out, it was replaced with a steel truss and I-beam approach spans salvaged from former bridges. Even the flooring was wood reclaimed from the old timber structure. Difficulty in replacing another bridge over the Cedar forced "the purchase by the State of a government surplus bridge in New Jersey, the shipping of it to our shop in Lincoln for some shop fitting and the delivery to the site."[117]

By the late 1940s, the country had largely recovered from the war. To a nation longing for security and prosperity, the suburban home became the ideal. Tract housing claimed corn fields and demanded roads which, when extended, spurred even further development. Within a decade, the interstate freeway system was conceived and under construction. As in past decades, bridge design continued to evolve as new technologies became available and as structural needs changed. Bridges built for primordial tractors and roadsters heroically stood the test of heavier vehicles, higher volume, and faster traffic, serving long past reasonable expectations. Their increasingly rapid replacement, however, has created an urgent need to record the survivors. From the humble concrete culverts over irrigation canals in the state's western counties to the complex trusses spanning the moody Missouri, these structures provide a tangible bridge between Nebraska's past and present.

Endnotes

[1]Martin E. Carlson, "The Development of Irrigation in Nebraska" (Ph.D. thesis, University of Nebraska, 1963), p. 41.

[2]Twain quoted in Nebraska Department of Public Works, *Fifteenth Biennial Report*, 1923-1924, p. 164.

[3]Weather statistics from Merlin P. Lawson, et al., *Climatic Atlas of Nebraska* (Lincoln: University of Nebraska Press, 1977), p. 46; bridge reconstruction records from John G. Mason, "A Report on Pile Foundations in Nebraska Highway Bridges" (Civil Engineer thesis, University of Nebraska, 1936), p. 7.

[4]For information on steamboating, see James C. Olson, *History of Nebraska* (Lincoln: University of Nebraska Press, 1966), pp. 103-104.

[5]De Smet quoted in Guy P. Dorsey, "Pioneer Highways and City Pavements," Part 1, *Nebraska Blue Print*, March 1931, p. 6; Olson, p. 54.

[6]For information on early trails, see Olson, pp. 54-66, and Dorsey,"Pioneer Highways and City Pavements," Parts 1 and 2, *Nebraska Blue Print*, March (pp. 5+) and April (pp. 7+) 1931.

[7]Harvey quoted in Dorsey, Part 1, p. 24; other information on route in Olson, pp. 106-107.

[8]National Highway Users Conference, *Military Roads: A Brief History of the Construction of Highways by the Military Establishment and a Gazetteer of the Military Roads in Continental United States* (Washington, D.C.: n.p., 1935). According to historian Walker D. Wyman, "the government itself had constructed bridges over most of the streams except Loup Fork; "Omaha: Frontier Depot and Prodigy of Council Bluffs," *Nebraska History Magazine* 17 (July-September 1936): 148.

[9]George E. Koster, "A Story of Highway Development in Nebraska," typescript, 1986, pp. 10-11; Olson, p. 87.

[10]Everett Dick describes construction of a sod bridge in *Conquering the Great American Desert: Nebraska* (Lincoln: Nebraska State Historical Society Press, 1975), p. 44:

> With the greatest of effort two trees were dragged to the stream and laid parallel from bank to bank about six feet apart. Poles were laid perpendicularly across these stringers at short intervals. This skeleton was then covered with brush and over the brush a thick layer of slough hay; over this a quantity of earth was spread. The passage of teams and wagons packed down the earth, and well-beaten tracks were formed across the causeway.

[11]For bridge fund details, see George Johnson, "The Development of Nebraska Highways," *Nebraska Blue Print*, March 1922, p. 3. On Means, see Dorsey, Part 2, p. 8. The Old Grand Island Bridge is mentioned in Nebraska Department of Public Works, *Monthly Report*, October 1921, p. 3; the Central City Bridge in *Monthly Report*, February 1922, pp. 16-17. For 1881 flooding, see Dick, p. 260.

[12]Quotes in Dorsey, Part 2, pp. 7-8. For information on John Burke, see Carlson, pp. 88-90.

[13]Dorsey, Part 2, p. 8.

[14]For an overview of truss bridges, see Donald C. Jackson, *Great American Bridges and Dams* (Washington, D.C.: Preservation Press, 1988), pp. 20-30; and J.A.L. Waddell, *Bridge Engineering*, vol. 1 (New York: John Wiley & Sons, 1916), pp. 18-22.

[15]Waddell, 23-27; Jackson, pp. 28-29.

[16]Dorsey, Part 2, pp. 7-8. For Beatrice bowstring, see Gage County Commissioners' Records, 6 October 1874, 7 February 1876, 15 July 1890, in Gage County Courthouse, Beatrice, Nebraska.

[17]Jack Singleton, "Meeting Nebraska's Bridge Problems," Part 1, *Nebraska Blue Print*, October 1931, p. 35.

[18]Daniel B. Luten, *Engineering News* 47 (17 April 1902): 304-305.

[19]See Nebraska Historic Bridge Inventory Forms for Bridge Numbers C001200904, C001205005P, C004111015, C005516205, C005520840R, C006703505P, C007403205, C007914525, C008700620, C008703105P, and C00871161. These and all other Nebraska historic bridge inventory forms cited in this study are in the Nebraska State Historical Society in Lincoln.

[20]Mason, pp. 9-10.

[21]Mason, p. 12; Singleton, pp. 35-50.

[22]Waddell, pp. 27-28.

[23]*Ibid.*, p. 17; John W. Oliver, *History of American Technology* (New York: Ronald Press, 1975), pp. 314-29; H.R. Schubert, "The Steel Industry," in *A History of Technology*, vol. 5, Charles Singer, et al., eds. (New York and London: Oxford University Press, 1958): 53-71.

[24]Victor C. Darnell, *A Directory of American Bridge-Building Companies*, Society for Industrial Archeology Occasional Publication, no. 4 (Washington, D.C.: Society for Industrial Archeology, 1984), pp. 17-18, 48, 50.

[25]Darnell, pp. 85-86.

[26]The Paxton and Vierling plant was moved to Carter Lake in 1940; company information in "Steel Plant in 75th Year," *Sunday World-Herald*, 2 October 1960, and David C. Beeder, "Steel Firm Marks 100th Year," *World-Herald*, 12 May 1985. Andrews Brothers is listed in Omaha City Directories, 1890-94, in Omaha Public Library. For information on Ward, see "Harvey T. Ward is Called," Tecumseh Chieftain, 13 February 1926; Dorsey, Part 2, pp. 7-8.

[27]Ironically, Lincoln's "poor workmanship" has survived to this day; see Nebraska Historic Bridge Inventory, Bridge Number C001811505.

[28]Drake's daughter Mary married Peter Kiewit, whose construction company had received half a billion dollars in federal highway construction contracts by the 1960s; the firm has also been involved in hydro-electric development in British Columbia, Minuteman missile site development, and several other massive projects. See Harold B. Meyers, "The Biggest Invisible Builder in the World," *Fortune*, April 1966, p. 147. Omaha Structural Steel Works, which was renamed Omsteel Industries, came into financial trouble in the late 1960s. For information on the company and on Towle, see Arthur C. Wakeley, ed., *Omaha: The Gate City and Douglas County, Nebraska*, vol. 2 (Chicago: S.J. Clarke Publishing Co.,

1917), p. 225; Sara Mollin Baldwin and Robert Morton Baldwin, eds., *Nebraskana* (Hebron, Neb.: Baldwin Co., 1932), p. 1202; Vaughn Gaddis, "Omaha Steel Works," *Nebraska Blue Print*, March 1947, p. 139; Harold Levinger, "Omaha Steel," *Nebraska Blue Print*, October 1949, p. 6; "Omsteel Firm Once Enviable," *World-Herald*, 8 April 1973. Allied Contractors is listed Omaha city directories from 1920 to 1937.

[29]*Designs of Wrought Iron Bridges built by the Wrought Iron Bridge Co. of Canton, Ohio* (Canton: Hartzell & Saxton, 1874), p. 18.

[30]Nebraska State Board of Irrigation, Highways and Drainage, *Tenth Biennial Report*, 1912-14, p. 222.

[31]Proceedings of the Clay County Commissioners: 29 March, 7 and 27 June, 1 and 29 August 1911; 10 January, 7 February, 12 March, 9 April 1912, in Clay County Courthouse, Clay Center, Nebraska. See also Nebraska Historic Bridge Inventory Form for Bridge Number C001812315.

[32]See, for example, Charlene K. Roise and Frederic L. Quivik, "North Dakota's Historic Bridges," draft, 1990.

[33]Proceedings of the York County Supervisors: 9 February 1916: York County Courthouse, York, Nebraska.

[34]Nebraska State Board of Irrigation, *Ninth Biennial Report, 1910-12*, p. 60; Nebraska State Board of Irrigation, Highways and Drainage, *Tenth Biennial Report*, 1912-14, p. 238.

[35]Nebraska State Board of Irrigation, *Ninth Biennial Report, 1910-12*, p. 56.

[36]Dorsey, Part 2, p. 21. Profile of Rosewater in *Pen and Sunlight Sketches of Omaha and Environs* (Chicago: Phoenix Publishing Co., 1892), p. 127. Rosewater was also involved with plans for a subway system in Washington, D.C., and was especially well known for his design of public works throughout the state and the nation: according to the article, he "has probably drawn up plans for the sewerage of more cities than any engineer west of Chicago." For Information on viaducts in general, see John Lethem, *Historical and Descriptive Review of Omaha* (Omaha: no pub., 1892), pp. 29-30; on the Sixteenth Street Viaduct, see Nebraska Historic Bridge Inventory Form for Bridge Number U1825J5505.

[37]Lethem, pp. 29-30. The 1887-88 structure, later known as the Ak-Sar-Ben Bridge, was widened in 1924 by cutting the original truss in two and inserting a heavier truss in the middle; see "Widening the Missouri River Highway Bridge at Omaha," *Engineering News-Record* 94 (18 June 1925): 1006-10.

[38]"Construction of Pivot Pier, Interstate Bridge, Omaha, Neb.," *Engineering News* 30 (23 November 1893): 410-12; "The 520-ft. Swing Span, Interstate Bridge, Omaha, Neb.," *Engineering News* 30 (7 December 1893): 448-49; "The Omaha Interstate Bridge," *Engineering Record* 47 (24 January 1903): 98-103. H.G. Schlitt, "Missouri River Progress Report," typescript, 20 September 1945, in files of the Bridge Department, Nebraska Department of Roads, Lincoln, Nebraska.

[39]Waddell, pp. 29-30.

[40]Olson, pp. 68-77, 112-115.

[41]Johnson, p. 1.

[42]Waddell, p. 21.; Singleton, p. 50.

[43]Clayton B. Fraser, "Behemoths: The Great River Bridges of George S. Morison," Historic American Engineering Record report prepared for the Rocky Mountain Regional Office of the National Park Service, October 1986, p. 43; "The Erection of the Omaha Bridge," *Engineering Record* 38 (27 August 1898): 268-69.

[44]Carl Condit, *American Building* (Chicago: University of Chicago Press, 1982), pp. 103-104.

[45]"The Nebraska City Bridge," *Engineering* 59 (11 January 1895): 43. For information on Whipple trusses, see Condit, 98-99, Jackson, pp. 24-27, and Waddell, p. 23.

[46]Condit, p. 104. It is interesting to note that when the 1885 bridge was replaced in 1916 by a still heavier structure of pin-connected Parker trusses, several of the old piers continued their patient service. For further information on the 1872, 1885, and 1917 Omaha bridges, see "Rebuilding the Missouri River Bridge of the Union Pacific R. R., Omaha, Nebraska," *Railway Review* 60 (10 February 1917): 191-94; and "Reconstruction of Union Pacific Railroad Bridge at Omaha," *Engineering* 103 (8 June 1917): 537-539.

[47]Waddell, p.25; "The Nebraska City Bridge," p. 43; "The Rulo Bridge," *Railroad and Engineering Journal* 61 (September 1887): 403-7; "The Blair Crossing Bridge," illustration in *Engineering* 44 (2 September 1887): 247.

[48]"Rulo Bridge," pp. 403-7; Waddell, p. 29.

[49]Donald D. Price, "Cement Plants and the Production of Portland Cement in Nebraska," *Nebraska Blue Print*, September 1931, p. 12.

[50]H. J. Kesner, "Some Resent Missouri River Bridges," *Nebraska Blue Print* 28 (May 1929): 9; photo caption in Nebraska Department of Public Works, *Fifteenth Biennial Report, 1923-24*, p. 98.

[51]For information on Office of Road Inquiry, see George E. Koster, p. 5. For details regarding the creation of the State Board of Irrigation, see its *First Biennial Report, 1895-96.*

[52]Koster, p. 11. Nebraska State Board of Irrigation, *Sixth Biennial Report, 1905-6*, p.11 and photograph opposite p. 11; *Seventh Biennial Report*, 1907-1908, photographs opposite pp. 109, 183.

[53]Koster, p. 13.

[54]John Doyle, "Public Highway Administration in Nebraska," M.A. thesis, University of Nebraska, 1951, p. 52.

[55]Aivars G. Ronis, "Nebraska State Aid Bridges, 1911-1936," report prepared for Nebraska Department of Roads, 1978; Nebraska State Board of Irrigation, *Ninth Biennial Report, 1910-12*, pp. 59-60.

[56]Nebraska State Board of Irrigation, *Ninth Biennial Report, 1910-12*, pp. 58-59.

[57]Nebraska State Board of Irrigation, Highways and Drainage, *Tenth Biennial Report, 1912-14*, pp. 220, 222-223, 232.

[58]Koster, p. 7.

[59]Fisher quote in Koster, p. 8; quote on Lincoln Highway route in Nebraska Department of Public Works, *Monthly Report*, September 1921, p. 7. A 4,580-foot section of the original Lincoln Highway in Douglas County, including an 81.5-foot, Pratt pony truss bridge, has been listed on the National Register of Historic Places. Due to rerouting of U.S. Highway 30, this section is now part of County Road 120. For further information in "Lincoln Highway Registration Form," nomination to National Register of Historic Places, in Nebraska State Historical Society, Lincoln. The Lincoln Highway, Meridian Road, and OLD Highway are mentioned in Nebraska State Board of Irrigation, Highways and Drainage, *Tenth Biennial Report, 1912-14*, p. 220-221; Nebraska Department of Public Works, *Monthly Report*, July 1922, p. 10.

[60]Nebraska State Board of Irrigation, Highways and Drainage, *Tenth Biennial Report, 1912-14*, pp. 231-232.

[61]For a general discussion of the development of concrete bridges in the United States, see Jeffrey A. Hess and Robert M. Frame, *Wisconsin Stone-Arch and Concrete-Arch Bridges, Historic Highway Bridges in Wisconsin*, vol. 1 (Wisconsin Department of Transportation, 1986).

[62]Information on Nebraska's cement industry in Price, p. 11.

[63]Nebraska Department of Public Works, *Monthly Report*, October 1919, pp. 17-18; state engineer quote and information on cement industry in State Board of Irrigation, Highways and Drainage, *Eleventh Biennial Report, 1915-16*, pp. 373-35.

[64]Nebraska Department of Public Works, *Monthly Report*, October 1919, pp. 17-18.

[65]Waddell, p. 16; Nebraska Department of Public Works, *Monthly Report*, October 1919, p. 17.

[66]Department of Public Works, *Monthly Report*, June 1920, p. 35.

[67]Nebraska Department of Public Works, *Fifteenth Biennial Report, 1923-24*, p. 164. Transverse joist girder bridges are discussed in a later section.

[68]Proceedings of the Webster County Commissioners: 26 February, 5 March, 12 August 1913, in Webster County Courthouse, Red Cloud, Nebraska.

[69]See Nebraska Historic Bridge Inventory Forms for the Onken Bridge, C006510245, and C007601725.

[70]See Nebraska Historic Bridge Inventory Form for C004402805P.

[71]Nebraska Department of Public Works, *Fifteenth Biennial Report, 1923-24*, p. 13-15.

[72]Summary of federal aid in John Doyle, p. 62; quote from Nebraska Department of Public Works, *Monthly Report*, October 1922, p. 9.

[73]Nebraska Department of Public Works, *Monthly Report*, June 1922, pp. 14-16; and *Sixteenth Biennial Report, 1925-26*, p. 154.

[74]Nebraska Department of Public Works, *Sixteenth Biennial Report, 1925-26*, p. 14; and *Monthly Report*, June 1922, p. 16.

[75]Nebraska Department of Public Works, *Thirteenth Biennial Report, 1919-20*, pp. 535-40; and *Monthly Report*, January 1921, pp. 37-38.

[76]*Ibid.*; Nebraska Department of Public Works, *Monthly Report*, February 1923, pp. 21-22; Nebraska Department of Roads, *Twenty-First Biennial Report, 1935-36*, p. 13.

[77]Nebraska Department of Public Works, *Monthly Report*, June 1919.

[78]Nebraska Department of Public Works, *Sixteenth Biennial Report, 1925-26*, p. 15; *Seventeenth Biennial Report*, 1927-28, p. 79.

[79]Nebraska Department of Public Works, *Fourteenth Biennial Report, 1921-22*, p. 264; *Seventeenth Biennial Report, 1927-28*, pp. 81-82.

[80]Nebraska Department of Public Works, *Sixteenth Biennial Report, 1925-26*, p. 25.

[81]Nebraska Department of Public Works, *Seventeenth Biennial Report, 1927-28*, p. 18; Koster, p. 22; Robert L. Cochran, "Nebraska's Highway System," *Nebraska Blue Print*, October 1926, pp. 9-10; Donald Cochran, "Nebraska's Highways Past-Present-Future," *Nebraska Blue Print*, May 1950, p. 186.

[82]Koster, p. 22; Nebraska Department of Roads and Irrigation, *Twenty-Second Biennial Report, 1937-38*, pp. 24-25; and *Twenty-Third Biennial Report, 1939-40*, p. iii.

[83]Nebraska Department of Public Works, *Monthly Report*, April 1920, p. 22.

[84]Ted Johnson, "A Discussion of Transverse Joist Girder Bridges," *Nebraska Blue Print*, March 1927, pp. 12-13; Nebraska Department of Public Works, *Fifteenth Biennial Report, 1923-24*, pp. 155-57; *Sixteenth Biennial Report, 1925-26*, pp. 226-32.

[85]Johnson, p. 13.

[86]Nebraska Department of Public Works, *Eighteenth Biennial Report, 1929-30*, p. 113.

[87]For information on the Meridian Bridge, see Nebraska Historic Bridge Inventory Form for Bridge Number S081.21468.

[88]Clayton B. Fraser, "Abraham Lincoln Memorial Bridge," Historic American Engineering Record report prepared for Iowa Department of Transportation, June 1987, pp. 20, 22, 33; W.G. Hill, "The Lincoln Memorial Bridge," *Nebraska Blue Print*, March 1929, pp. 5-6.

[89]Don Loutzenheizer, "The Waubonsie Bridge," *Nebraska Blue Print*, December 1930, p. 5; Levinger, p. 6.

[90]Loutzenheizer, pp. 5, 26.

[91]See Nebraska Historic Bridge Inventory Forms for S09207164, C003500105P and C003505305.

[92]Nebraska Department of Public Works, *Eighteenth Biennial Report, 1929-30*, p. 112.

[93]Nebraska State Board of Irrigation, Highways and Drainage, *Eleventh Biennial Report, 1915-16*, pp. 452-533.

[94]Nebraska Department of Public Works, *Nineteenth Biennial Report, 1931-32*, pp. 78-79; Nebraska Department of Roads and Irrigation, *Twentieth Biennial Report, 1933-34*, p. 43; Koster, pp. 35-38.

[95]Nebraska Department of Roads and Irrigation, *Twentieth Biennial Report, 1933-34*2, pp. 44-46; Koster, 35-38.

[96]Nebraska Department of Roads and Irrigation, *Twenty-First Biennial Report, 1935-36*, p. 75.

[97]*Ibid.*, p. 15.

[98]Justin Nicolet, "Fifty-six Bridges to Span New Power Canal," *Engineering News-Record* 117 (6 August 1936): 181-85.

[99]Nebraska Department of Roads and Irrigation, *Twenty-First Biennial Report, 1935-36*, p. 119.

[100]Nebraska Department of Roads and Irrigation, *Twentieth Biennial Report, 1933-34*, p. 80; *Twenty-First Biennial Report, 1935-36*, pp. 119, 124; *Twenty-second Biennial Report, 1937-38*, p. 72.

[101]Nebraska Department of Public Works, *Nineteenth Biennial Report, 1931-32*, pp. 74-75; Nebraska Department of Roads and Irrigation, *Twentieth Biennial Report, 1933-34, p. 80*; *Twenty-Second Biennial Report, 1937-39*, p. 70; *Twenty-Third Biennial Report, 1939-40*, pp. 60-63.

[102]Nebraska Department of Roads and Irrigation, *Twentieth Biennial Report, 1933-34*, p. 84.

[103]Ibid, pp. 34, 84-86; Nebraska Department of Roads and Irrigation, *Twenty-Second Biennial Report, 1937-38*, p. 42.

[104]Nebraska Department of Roads and Irrigation, *Twenty-Second Biennial Report, 1937-38*, pp. 70-71.

[105]Josef Sorkin, "Economy through Continuity in Girder-Beam Bridges," *Engineering News-Record* 3 (26 October 1933): 496-98.

[106]Josef Sorkin, "Design of Highway I-Beam Bridges; Simple, Continuous and Cantilever Spans," Civil Engineer thesis, University of Nebraska, 1936; Nebraska Department of Roads and Irrigation, *Twentieth Biennial Report, 1933-34*, pp. 88-90.

[107]Nebraska Department of Public Works, *Nineteenth Biennial Report, 1931-32*, pp. 73-74.

[108]John G. Mason and Josef Sorkin, "Bryan Bridge Adjudged Most Beautiful Bridge in Class C Competition," *Nebraska Blue Print*, February 1934, pp. 97-99.

[109]"Building a Bridge for a Future River Channel," *Engineering News-Record* 114 (23 May 1935): 727-32.

[110]E.E. Howard, "New Pier Design for Deep Overburden," *Engineering News-Record* 123 (23 November 1939): 687-88.

[111]Harrington and Cortelyou, "Missouri River Bridge at Rulo," general plan and elevation, date obscured on microfilm copy (probably 1938); H.G. Schlitt, Nebraska Department of Roads and Irrigation, to V.W. Enslow, Missouri Highway Commission, letter, 29 October 1945; Byrd, Tallamy, MacDonald and Lewis, "In-Depth Inspection, Condition Report and

Structural Analysis for US-159, Rulo Bridge over Missouri River," report prepared for Nebraska Department of Roads, November 1986. All are available at the Bridge Department, Nebraska Department of Roads.

[112]Nebraska Department of Roads and Irrigation, *Twenty-Fourth Biennial Report, 1941-42*, pp. 6, 9, 109, 113.

[113]Nebraska Department of Roads and Irrigation, *Twenty-Fifth Biennial Report, 1943-44*, pp. 85-87.

[114]Nebraska Department of Roads and Irrigation, *Twenty-Sixth Biennial Report, 1945-46*, p. 3.

[115]*Ibid.*, pp. 67, 171.

[116]*Ibid.*, p. 3.

[117]*Ibid.*, pp. 66-67, 175, 181-82.

F. Associated Property Types

I. **Name of Property Type** Metal Truss Highway Bridges

II. **Description** Truss bridges are made from sets of parallel, two-dimensional webs or leaves formed from a series of geometric shapes, usually triangles. The webs are built up from smaller members, such as channels, angles, rods, bars and plates. The configuration of these members determines the distribution of compression and tension, the principle stresses acting on any truss. The resulting pattern defines the truss style. In a Howe truss, for example, the diagonals are in compression and the verticals are in tension, while the opposite is true for a Pratt. (For a discussion of truss styles and methods of construction, see Section E: II, III, IV, V.) In addition to truss styles, bridges are identified by the relative position of the truss to the roadway. When the upper chord of a truss is at the level of the bridge floor, it is known as a deck truss. If, on the other hand, the lower chord of the truss is near the deck, and the top chords are connected above the roadway, the structure is called a through or overhead truss. If the upper chords are not connected, it is referred to as a pony truss.

Materials used in the construction of truss bridges have changed over the centuries. Earliest examples were made entirely of wood. As wrought and cast iron became widely available in the early 1800s, these materials were used in conjunction with wood members, creating "combination" bridges. Metal fabrication methods improved by the mid-19th century, making all iron bridges more economical, particularly when the material's longer life was weighed. Improvements in steel production in the last half of the 19th century led steel to completely usurp iron's role in metal bridge construction by the 1890s. The advantages of steel were further enhanced by the subsequent development of composite steels. (For more information on the production of iron and steel, see Section E: III.)

The means of connecting truss members is an important feature. Pin connections were popular in the 19th century, particularly for Pratt styles, because they facilitated bridge erection under primitive field conditions. Pins were, however, a flexible connection, which was weakened over time by bridge vibrations. Riveting provided a sturdier bond, and was used extensively on components assembled at bridge manufacturing plants. This method was virtually impossible at most bridge construction sites, however, until there were improvements in portable pneumatic riveting equipment around the turn of the century. Welding was not widely accepted for bridge construction until the 1940s, well after the era of truss bridge design.

Although wood and combination truss bridges were apparently built in 19th century Nebraska, none survive. A handful of iron bridges remain from the last decades of the 1800s, primarily bowstring and Pratt through and pony trusses. By far the largest group of surviving truss bridges are steel ponies, with a smaller concentration of steel through trusses. Nebraska maintained a decided preference for the Pratt truss style into the 1920s, long after other states adopted the Warren, so the Pratt is by far the best represented among existing truss bridges. By the late 1920s, the state converted to the Warren. Nebraska also propagated plans for modified Warrens, such as the camelback, with its five-sloped upper chord. Although girder bridge designs had virtually replaced the pony and trough truss for small- to mid-sized spans by the mid-1930s, monumental truss bridges continued to be built over major rivers.

_x_ See continuation sheet

_x_ See continuation sheet for additional property types

III. **Significance** Metal truss highway bridges in Nebraska may be eligible for listing in the National Register under Criterion A for their association with events that have made a significant contribution to the broad historical patterns of the country, the state or the region. Specifically, bridges that have played an important role in the development of the state's highway transportation system and, hence in the exploration and settlement of the area. For example, a structure might be significant by its association with a particular route, such as the Lincoln or Meridian Highways, or because it was built with assistance from the State Aid Bridge Fund or federal Depression-era relief programs. Bridges may, in addition, be eligible under Criterion B for their association with a significant person, as long as the "significant person" was not the designer or builder of the bridge. A bridge can be eligible by virtue of its designer or builder, but this falls under Criterion C. Indeed, most eligible bridges qualify under Criterion C as structures of engineering significance. This can encompass a broad range of considerations. For instance, a bridge can qualify under Criterion C as a well-preserved example of a once common type, or as a unique example of an unusual type.

Metal truss bridges became ubiquitous throughout the state in the late 19th and early 20th centuries. Bridge companies sent salesmen to beseige county commissioners in rapidly growing regions. Truss bridges were relatively easy to erect, thanks to prefabricated webs, and they were sturdier than simple stringer spans. They served, with relatively little maintenance, for decades, carrying load and traffic demands that far exceeded what many had been designed to bear.

The evolution of truss bridges illustrates major historical trends since Nebraska's settlement. The earliest trusses used primitive materials - wood and iron - and simple designs. By the 1890s, the overwhelming adoption of steel components reflected an advance from the 19th century industrial revolution to the modern age of technology. Likewise, the relatively small regional bridge manufacturing firms were being absorbed by the big corporate conglomerates that came to dominate most sectors of 20th century industry. The growing role of state and federal government can be traced in efforts to standardize bridge plans and specifications. At the same time, engineering grew into a professional, specialized field. As technology and training advanced, new ideas such as structural continuity and cantilevering were applied to venerable truss forms. The new technology, however, ultimately led to the truss's demise in the 1930s, as developments in design and production fostered the creation of different, more economical styles.

IV. **Registration Requirements** The period of significance for metal truss highway bridges begins in 1870, the decade which saw the erection of Nebraska's earliest extant structures of this type. The period of significance ends with the year 1942, the fifty-year cutoff date maintained by the National Register. Alterations made during the period of significance may be considered part of the bridge's historic fabric. Integrity of the structure's historic materials and design is essential for any bridge to qualify for the National Register under any criteria. The definition of "integrity" may vary, however, depending on the criterion. Because location is of primary importance under Criterion A, a structure will rarely qualify under this criterion if it does not remain on its original site. Location can also have significance under Criterion B, but the correlation is not as universal. When focusing on engineering under Criterion C, the mobility of metal trusses is actually an important trait, since the structures were designed to be moved. Movement of a structure under this criterion might not necessarily detract from its historic integrity. On the other hand, structural integrity is of vital importance for those bridges considered under Criterion C. In engineering terms, a truss bridge is considered to be comprised of a group of distinct structural systems, rather than a single entity. These systems, in general order of importance under Criterion C, are the superstructure, the substructure, the floor and approach spans, if any. The super- and substructure of a bridge, for instance, may have retained a high degree of physical integrity, while the floor system and approach spans may have been altered, replaced or even removed, and the bridge may still be considered eligible for registration. Loss of physical integrity may be mitigated by technological significance for unique or rare structural types.

Specific considerations for eligibility under Criterion A:

1. **Early and/or prominent product of the State Aid Bridge Fund:** The State Aid Bridge Fund was established in 1911 to provide assistance to counties to bridge waterways 175-feet wide or greater. This requirement was later decreased to 100 feet. A total of 77 bridges were built as a result of this fund before the program was discontinued in 1936. Most have since been replaced or substantially altered. The State Aid program represents an early government effort to improve Nebraska's road system.

2. **Important crossing of a major early automobile route:** Several early 20th century transcontinental automobile routes, such as the Lincoln and Meridian highways, passed through Nebraska. Bridges carrying these routes may be significant for their association with the early development of the nation's highway system.

Specific considerations for eligibility under Criterion C:

1. **Earliest well-preserved example of a style:** Prior to 1913, when the state began requiring the use of standard plans for all county bridge construction, metal truss bridge designs displayed the wide diversity of styles available throughout the country in the late 19th and early 20th centuries. Some bridges dating from 1905 to 1913 feature early designs developed by the state engineer's office. Because of their age and lightweight construction, these structures have become a target for efforts to replace substandard bridges and are becoming increasingly uncommon. Since cast and wrought iron bridge members were virtually eliminated by the availability of steel by the 1890s, these bridges are extremely rare and worthy of preservation.

2. **Rare survivor of a once common structural type:** This includes bridges built both before and after the advent of state standard plans. The overhead truss, popular well into the 20th century, is now particularly endangered by bridge replacement programs.

3. Exceptional example of work by an important engineer, architect, or firm: This includes local, regional and national companies and designers. Among the nationally and regionally prominent bridge building companies working in late 19th and early 20th century Nebraska were the King Bridge Company (Cleveland, Ohio); the Wrought Iron Bridge Company (Canton, Ohio); the Canton Bridge Company (Ohio); the Edge Moor Bridge Works (Wilmington, Delaware); the Milwaukee Bridge and Iron Works and the Wisconsin Bridge and Iron Company (both in Milwaukee, Wisconsin); the Union Bridge Company (New York); the American Bridge Company (New York); George E. King, and Nathaniel Stark (all of Des Moines); the Gillette-Herzog Manufacturing Company and the Minneapolis Steel and Machinery Company (Minneapolis); J.W. Hoover, A.M. Blodgett, and the Kansas City Bridge Company (Kansas City); and the Missouri Valley Bridge and Iron Works (Leavenworth). Major firms based in Nebraska include the Standard Bridge Company, Omaha Structural Steel Works, Allied Contractors, and the Western Bridge Company (all in Omaha); and the Woods Brothers Construction Company (Lincoln). Local bridge builders include Harvey Ward (Tecumseh) and John B. Gilligan (Falls City). Engineers prominent in Nebraska bridge design include George S. Morison; Harrington, Howard and Ash (Kansas City); Ash, Howard, Needles and Tammen (Kansas City); Harrington and Cortelyou (Kansas City); Sverdrup and Parcel (St. Louis); and Josef Sorkin (Nebraska Highway Department).

4. Built with patented or special designs: While Pratt and Warren trusses were in the common domain by the late 19th century, some bridge manufacturers developed, promoted, and protected patents for bridges of unusual design, such as the King bowstring. Other designs, like the bedstead truss, enjoyed a very brief period of popularity.

5. Monumental bridge: Spanning major Nebraska rivers was a major undertaking usually requiring many years and great expense to complete. The resulting structures, which became instant landmarks, featured the latest technology and displayed the aesthetic sensibilities of the era. They may be significant under both Criteria A and C.

6. Monumental span: Long spans, particularly those in excess of 100 feet, were less amenable to standardization and sometimes stretched the limits of available technology. In addition, they were built much less frequently than shorter spans.

7. Design utilizing new technology, or technology rarely used in Nebraska: In developing bridges for Nebraska, engineers were faced with a variety of physical and economic challenges. This forced creativity in design, leading, for example, to experiments with continuous and cantilevered spans. It sometimes led to selection of a style unusual for the state, such as a vertical lift span. It also attracted attention to new techniques, like welding.

8. Bridges with exceptional aesthetic merit: Most bridges built in the state are strictly utilitarian. Occasionally, however, a structure stands out by virtue of its design or because of the quality of the craftsmanship displayed in its construction. The interrelationship of a bridge and its site can also have aesthetic value.

I. **Name of Property Type** Metal Beam Highway Bridges

II. **Description** Beam structures are among the most rudimentary of bridge designs. Ornamentation, if any, is usually limited to railings. Variations in style result from the composition and orientation of the beams. Like truss bridges, construction contracts for beam bridges were often let annually by a county. Because of the simplicity of design, this style was easily built by local contractors using readily available materials. Beam spans identified in Nebraska can be classified as stringer, girder, plate girder, and transverse joist girder.

Stringer and girder spans consist of a series of beams parallel to the roadway, covered with one or more layers of flooring. Originally built of wood, this style adopted stronger, longer-lasting, metal I-beams when these became available in the 19th century. Initially built up from bars and angles, I-beams became cheaper and sturdier when steel mills developed techniques to roll them as a single piece. Span length was limited by the beam's depth, and the depth, in turn, was dependent upon manufacturing capabilities. Stringer bridges included in early state standard plans were typically 15 to 32 feet in length. Girders were basically large-scale I-beams, and the first bridges utilizing them were essentially simple stringer structures. During the early 1920s, maximum I-beam span length increased from fifty to sixty feet. By 1928, when steel mills developed the capacity to expand I-beam web depth from 30 to 36 inches, feasible simple span length jumped from 62.5 to 75 feet. A major breakthrough came when it was discovered that much longer spans could be economically created from existing web depths using the principles of continuity and cantilevering.

Plate girders were developed to carry extremely heavy loads, which demanded web depths greater than what could be feasibly manufactured as a single rolled beam. The girders are made from plate and angle sections riveted into a solid beam. These are used to build through or deck bridges. Because of their strength and stability, plate girder spans have often been used for highway-railroad grade separations.

An interesting variation on the beam bridge is the transverse joist girder bridge, developed in Nebraska in the early 20th century. Robert Z. Drake, who founded the Standard Bridge Company of Omaha and developed the built-up H-beam pile, is credited with inventing this design as well as the multiple punch necessary for its manufacture. As the name implies, joists run perpendicular to the roadway, fastened at each end to the web of I-beam girders. Used in both through and deck configuration, the design was relatively inexpensive, because the components could be easily standardized, minimizing custom design work for fabrication. Erection was quick, using a small labor force and requiring no expensive falsework. By the late 1910s, transverse joist girder bridges were added to the state's set of standardized plans. Spans were typically fifty to sixty feet for major river bridges, with roadway widths ranging from 16 to 20 feet. By 1927, there were more than 1,000 transverse joist girder bridges in the state. As with every bridge style, the transverse joist girder had some drawbacks. Economics of construction dictated a maximum width of twenty feet, and widening the bridges at a later date was difficult and expensive. Ever increasing traffic volume demanded wider roadways, sealing the fate of the transverse joist girder bridge. Their construction had ceased, for the most part, by the late 1920s.

III. **Significance** Metal stringer and girder highway bridges in Nebraska may be eligible for listing in the National Register under Criterion A for their association with events that have made a significant contribution to the broad historical patterns of the country, the state or the region. Specifically, bridges that have played an important role in the development of the state's highway transportation system and, hence in the exploration and settlement of the area. For example, a structure might be significant by its association with a particular route, such as the Lincoln or Meridian Highways, or because it was built with assistance from the State Aid Bridge Fund or federal Depression-era relief programs. Bridges may, in addition, be eligible under Criterion B for their association with a significant person, as long as the "significant person" was not the designer or builder of the bridge. A bridge can be eligible by virtue of its designer or builder, but this falls under Criterion C. Indeed, most eligible bridges qualify under Criterion C as structures of engineering significance. This can encompass a broad range of considerations. For instance, a bridge can qualify under Criterion C as a well-preserved example of a once common type, or as a unique example of an unusual type.

Engineers and entrepreneurs in Nebraska made several significant contributions to bridge design. Early plate-girder bridges were built to separate highway and railroad traffic, reflecting both the importance of the railroads in Nebraska's early development and the growing prominence of the automobile in the early 20th century. In the 1910s, the transverse joist girder was invented in the state and became very popular through the 1920s. In the 1930s, state highway engineers tested the limits of the principles of continuity and cantilevering: the cantilevered 115-foot central span of the 679-foot Loup River bridge north of Cairo was credited as being the longest of its type in the world at the time of its construction in 1934. (See Section E: VIII for information on plate girders and grade separations; Section E: IX for transverse joist girders; and Section E: XI for continuous and cantilevered bridges.)

IV. **Registration Requirements** The period of significance for metal stringer and girder highway bridges begins in 1900, the year in which Nebraska's earliest extant structure of this type was built. The period of significance ends with the year 1942, the fifty-year cutoff date maintained by the National Register. Alterations made during the period of significance may be considered part of the bridge's historic fabric. Integrity of the structure's historic materials and design is essential for any bridge to qualify for the National Register under any criteria. The definition of "integrity" may vary, however, depending on the criterion. Because location is of primary importance under Criterion A, a structure will rarely qualify under this criterion if it does not remain on its original site. Location can also have significance under Criterion B, but the correlation is not as universal.

When focusing on engineering significance under Criterion C, location is not necessarily a factor. However, metal stringer and girder bridges are rarely moved *in toto*. Material from a beam bridge may be salvaged and used for another structure, but this is often a different design. Because most of the beam structure is visible only from beneath the bridge, the survival of original railings, piers and other details is of particular importance.

Specific considerations for eligibility under Criterion A:

1. **Early and/or prominent product of the State Aid Bridge Fund:** The State Aid Bridge Fund was established in 1911 to provide assistance to counties to bridge waterways 175-feet wide or greater. This requirement was later decreased to 100 feet. A total of 77 bridges were built as a result of this fund before the program was closed out in 1936. Many have since been replaced or altered. The State Aid program represents an early government effort to improve Nebraska's road system.

2. **Important crossing of a major early automobile route:** Several early 20th century transcontinental automobile routes, such as the Lincoln and Meridian highways, passed through Nebraska. Bridges carrying these routes may be significant for their association with the early development of the nation's highway system.

Specific considerations for eligibility under Criterion C:

1. **Earliest well-preserved example of the style:** Because simple beam bridges were easy to construct, they became extremely common throughout Nebraska by the early 20th century. Although many survive, most have experienced some alteration. Stringer and girder spans have often been widened and reinforced, harming their integrity. Also, older stringer bridges are sometimes scavenged for members which are recycled for use in new bridges.

2. **Rare survivor of a once common structural type:** This is especially applicable to transverse joist girder bridges, which were difficult to widen in response to increased traffic and loads. Most, therefore, have been replaced.

3. **Exceptional example of work by an important engineer or firm:** This includes local, regional and national companies and designers. Among the prominent bridge building companies responsible for erecting beam spans in late 19th and early 20th century Nebraska were the Wrought Iron Bridge Company (New York, Chicago, and Kansas City); the Canton Bridge Company (Ohio); the American Bridge Company (New York); and the Standard Bridge Company, Omaha Steel Works, and the General Construction Company (all of Omaha). Significant engineering work was done by the Nebraska Department of Roads, particularly Josef Sorkin.

4. **Monumental bridge:** Spanning major Nebraska rivers was a major undertaking usually requiring many years and great expense to complete. The resulting structures, which became instant landmarks, featured the latest technology and displayed the aesthetic sensibilities of the era. They may be significant under both Criteria A and C.

5. **Design utilizing new technology, or technology rarely used in Nebraska:** In developing bridges for Nebraska, engineers were faced with a variety of physical and economic challenges. This forced creativity in design, leading, for example, to experiments with continuous and cantilevered spans. It also attracted attention to new techniques, such as welding.

6. **Bridge with exceptional aesthetic merit:** Most bridges in the state are strictly utilitarian. Occasionally, though, a structure stands out by virtue of its design or the quality of craftsmanship in its construction. The interrelationship of a bridge and its site can also have aesthetic value.

I. **Name of Property Type** Concrete and Stone Highway Bridges

II. **Description** Stone can be found in many areas of Nebraska, but stone arch bridges were rarely built in the state, perhaps because of the degree of skilled craftsmanship and the amount of labor involved in their erection. Nebraska was also well supplied with the raw materials necessary to make concrete, but the state was slow to develop its own industry. Although there were a number of lime kilns in operation in the southeastern part of the state by the late 19th century, all concrete for bridge and pier construction was probably imported from out of state until the early 20th century. It was not until 1915 that a cement plant opened (or perhaps reopened) at Superior. Although larger concrete structures were built throughout the state, construction of smaller concrete bridges was concentrated in the state's southeast corner, a logical development considering that Superior was the probable source of the cement.

Arches are an ancient form. They come in a number of profiles, ranging from a point-topped lancet to a broad ellipse to an essentially flat line. An arch's curve is determined by the number and relationship of "centers" used in its design and the length of the radii extending from these centers. Regardless of their profile or material, all arches have common components. The arch springs from a pair of imposts, which carry the base of the arch. The inner curve of the arch is called the intrados; the outer edge, the extrados. If the extrados is delineated by a molding, this is known as the archivolt. The triangular area buttressing the arch between the crown and the impost is the haunch. Individual stones making up the arch are voussoirs, topped by a keystone at the crown. Arches require a degree of skill - or luck - in design to balance the forces of thrust and gravity, but they are quite stable when successfully erected. In all cases, the bridge deck rests on the arch. Although concrete through-arch bridges were promoted elsewhere in the region between 1912 and the mid-1930s, apparently none were built in Nebraska.

Both stone and concrete arch bridges require falsework to maintain the arch during construction. Workmanship on stone arch bridges varies widely. Stones can be carefully dressed ashlar laid in regular courses, or rather crude agglomerations of irregular fieldstones. Concrete is a more malleable material. The aggregate used in the concrete influences the bridge's color and texture. Concrete bridges can be easily ornamented with cast designs reflecting the aesthetic inclinations of the period, or covered with stone veneer. True stone arch bridges rely on the equilibrium inherent in the arch design. Ample amounts of mortar, however, are often the real glue sustaining an arch. Concrete arch bridges usually require metal reinforcing bars to maintain their strength, since concrete is strong in compression but weak in tension. If the haunch is left unfilled in a concrete arch bridge, it is known as an open spandrel design; if filled, a closed spandrel. Plans for closed spandrel arch bridges were propagated early on by the state engineer's office. Multiple-arch structures over major rivers built in the 1910s and early 1920s have spans ranging from 50 to about 70 feet; single spans on secondary roads are usually under 50 feet. (For a more detailed description of these bridges, see Section E: VII.)

The typical rigid-frame arch is also broad, and very flat. Because of these very shallow proportions, reinforcing plays a particularly large role in this design. Although this style was developed in New York in the early 1920s, it was not introduced in Nebraska until the following decade. Rigid frames were often used to separate highway traffic from railroads and other highways. Their monolithic face provided an opportunity for artistic expression. Many display Streamline Moderne or Classical Revival motifs, which were popular in the 1930s. Stone veneer on others is typical of the labor-intensive work of the federal work relief programs. (For more information on the rigid frame style, see Section E: XI.)

Simple reinforced-concrete slab bridges were an alternative to metal or timber stringer structures. The earliest known example remaining in Nebraska dates from 1908. As the name implies, a slab span is cast in forms as a single unit with steel reinforcing bars. Early 20th century concrete slabs were created at the bridge site, with formwork built by local carpenters. The plain appearance of this functional design was varied by choice of railings, which ranged from solid parapets to Classical Revival balustrades.

III. Significance Concrete arch bridge construction in Nebraska occurred primarily during two periods: a flurry of concrete filled-spandrel bridge building in the 1910s, and widespread use of the concrete rigid-frame design in the 1930s. Both phases were in large measure the result of the contemporary vogue in bridge design at the Nebraska highway department. Concrete arch bridge designs, with spans ranging from 10- to 50-feet, were among the first standard plans developed by the state engineer's office circa 1912. The state enthusiastically promoted the use of concrete construction, claiming that the cost was comparable to that of other bridge types, particularly given concrete's reputation for permanence. While concrete arches were used for some small bridges, the style was most visible as the choice for a number of major river crossings in the 1910s. These graceful bridges gave a sense of permanence to the state's road system which was being transformed during this period from a hodgepodge of 19th century pioneer trails to a modern, interstate highway network. Moreover, many were among the earliest products of the State Aid Bridge Fund, established in 1912, which was responsible for the erection of 17 multiple-arch bridges in the ensuing years. Based on these considerations, concrete arch structures may merit inclusion in the National Register under both Criteria A and C.

The state's early infatuation with the concrete arch was soured, however, by structural problems, including bridge failures, in the early 1920s, leading to the decline in use of this style. Concrete arches came into vogue again the following decade, but in a different guise: the rigid frame. This style was popular during the period when federal relief funds pumped millions of dollars into road improvement projects, both to upgrade public works and to employ those out of work due to the Depression. Rule changes permitted federal funding to be used for urban construction for the first time. Hence, rigid-frame bridges often are significant under both Criteria A and C.

Stone arch bridges are an anomaly in Nebraska. Although the material was readily available in many parts of the state, stone construction is slow and labor intensive. While these conditions usually meant that other bridge types were selected, the stone arch enjoyed a brief period of popularity in the 1930s when federal public works programs sought to maximize employment. Thus stone arch bridges, like concrete, may have significance under Criteria A and C.

Their design straightforward, concrete slab bridges are utilitarian and numerous in Nebraska. They were rarely used for significant crossings of major routes but, rather, in locations where function was more important than form. As such, their significance rests primarily on what they reveal about highway development and the early cement industry in the state.

IV. Registration Requirements The period of significance for masonry highway bridges begins in 1908, the year when Nebraska's earliest known concrete bridge was built. The period of significance ends with the year 1942, the fifty-year cutoff date maintained by the National Register. Alterations made during the period of significance may be considered part of the bridge's historic fabric. Integrity of the structure's historic materials and design is essential for any bridge to qualify for the National Register under any criteria. Since it is virtually impossible to move masonry bridges, integrity of location is a given. Masonry highway bridges may be eligible for the National Register under Criterion B for their association with a significant person, but this is rare. Most often, these bridges will have significance under Criteria A or C.

Specific considerations for eligibility under Criterion A:

1. **Early and/or prominent product of the State Aid Bridge Fund:** The State Aid Bridge Fund was established in 1911 to assist counties in bridging waterways 175-feet wide or greater. This requirement was later decreased to 100 feet. A total of 77 bridges were built as a result of the

program before it was closed out in 1936. Many have since been altered or replaced. The State Aid program was an early government effort to improve Nebraska's road system.

2. **Important crossing of a major early automobile route:** Several early 20th century transcontinental automobile routes, such as the Lincoln and Meridian highways, passed through Nebraska. Bridges carrying these routes may be significant for their association with the early development of the nation's highway system.

3. **Outstanding example of federal work relief programs of the Depression era:** Federal work programs in the 1930s, particularly those funded by the Works Progress Administration, led to construction of a number of stone-arch and rigid-frame bridges in the state. The most significant display careful craftsmanship and creative design.

Specific considerations for eligibility under Criterion C:

1. **Earliest use of the material:** Although the railroads began experimenting with concrete in the late 1800s, concrete highway bridges did not appeared in Nebraska until the first decade of the 20th century. Since cement was apparently not produced in the state until 1915, earlier concrete bridges were built with imported material.

2. **Rare survivor of a once common structural type:** Early boosters of concrete bridges heralded the material's permanence. While concrete arches were more durable than the wooden structures they often replaced, concrete, too, was susceptible to high water, ice flows and deterioration. As a result, many concrete arches have been replaced, raising the need to monitor the survivors.

3. **Example of a rare structural type:** Since stone arch bridges are unusual in Nebraska, well-preserved and well-documented examples are extremely significant.

4. **Monumental bridge:** Spanning large Nebraska rivers was a major undertaking usually requiring many years and great expense to complete. The resulting structures, which became instant landmarks, featured the latest technology and displayed the aesthetic sensibilities of the era. They may be significant under both Criteria A and C.

5. **Bridge with exceptional aesthetic merit:** Most bridges built in the state are strictly utilitarian. Occasionally, however, a structure stands out by virtue of its design or because of the quality of the craftsmanship displayed in its construction. The interrelationship of a bridge and its site can also have aesthetic value.

I. **Name of Property Type** Timber Highway Bridges

II. **Description** Timber is well suited for simple stringer spans, and this is its most common - and only extant - form in Nebraska. Timber was used alone and in combination with iron to build truss bridges in 19th century Nebraska, but none of these structures is known to remain. Stringer spans usually measure 25 feet or less. The carrying capacity of a stringer is limited by the relationship between its diameter and length: the larger the diameter, the longer the feasible span. Railings on timber bridges are usually simple, often made of wood. Decks, bents and abutments are frequently timber as well, although decking is sometimes covered with asphalt. Bridge timber is almost always treated with a preservative, such as creosote oil. Railroads took the forefront in developing methods to treat timber in the late 19th century. More recently, laminated timber members have also been incorporated into bridge design.

III. **Significance** The broad prairies of Nebraska held few trees, and so most lumber for construction had to be imported from outstate. This lack of "free" wood and the relative impermanence of timber, compared to other materials used to build bridges, diminished the desirability of timber bridges. Because the material was cheaper in the short-run, however, timber bridges were built in Nebraska, especially for small bridges on little-traveled roads. Erection of larger timber structures was most likely when flooding demolished a large number of bridges, straining county funds for bridge replacement. Timber was also used when other materials were difficult to obtain. During World War II, both steel and concrete were included on the War Department's "Priorities Critical List" of materials essential to the military effort. Most bridge plans were put on hold during this period, due to shortages of both material and labor, but it was necessary to complete bridges on roads serving munitions plants, airports, and other important military sites. Timber became one of the few options for bridge construction.

IV. **Registration Requirements** The period of significance for timber highway bridges begins in 1916, the year when Nebraska's oldest extant timber bridge was built. The period of significance ends with the year 1942, the fifty-year cutoff date maintained by the National Register. Alterations made during the period of significance may be considered part of the bridge's historic fabric. Integrity of the structure's historic materials and design is essential for any bridge to qualify for the National Register under any criteria. Timber highway bridges may be eligible for the National Register under Criterion B for their association with a significant person, but this is rare. Most often, these bridges will have significance under either Criteria A or C.

Specific consideration for eligibility under Criterion A:

1. **Association with major historical events:** Nebraska's rivers have been notorious for the their periodic spring rampages, resulting in destruction of scores of bridges. Local and county governments were often forced to undertake significant rebuilding programs to replace these structures. Few well-documented, early 20th century examples exist. By the mid-20th century, timber was used primarily for short stringer spans. With restrictions on steel and other materials imposed by World War II, however, the construction of large timber bridges experienced a revival, and these bridges thus obtain significance by virtue of their relation to the war effort.

Specific consideration for eligibility under Criterion C:

1. **Rare surviving example of once common type:** Scores of simple wood pile bridges were built in Nebraska in the late 19th and early 20th centuries. Because of the natural deterioration of wood over time, very few survive.

G. Summary of Identification and Evaluation Methods

Discuss the methods used in developing the multiple property listing.

The Nebraska Historic Bridge Inventory, which formed the basis for this Multiple Property Documentation, was undertaken for the Nebraska Department of Roads (NDOR) with the cooperation of the Nebraska State Historic Preservation Office. The study presents an inventory and evaluation of highway bridges currently in use on the state, county and city road systems. By inventorying roadway bridges on a statewide basis, the study provides a data base and the contextual background by which individual structures may be evaluated for historical and technological significance. This will aid long-range policy and funding decisions at the outset of the planning process and allow enlightened review of proposed maintenance, rehabilitation and replacement projects. Additionally, it will help to guide mitigation measures for construction projects in the future which affect eligible structures. The inventory was directed to three specific objectives:

> **To inventory several types of vehicular bridges, giving descriptions of structural configuration and dimensions, present state of integrity and physical condition, location and ownership, with historical and engineering data.**
>
> **To present a historical overview of bridge development and construction.**
>
> **To assess all bridges in the inventory for relative significance and potential eligibility for the National Register of Historic Places (NRHP) based on historical and technological significance from a comprehensive viewpoint.**

The study reviewed records for some 8700 pre-1947 structures in the state - and, to a lesser extent, virtually all of the publicly owned bridges in Nebraska, regardless of construction date. After an initial winnowing process, it focused on 743 bridges and grade separations, including the 99 nominated structures listed later in this section. These encompass several structural types: concrete slab, girder and arch; timber stringer; and steel stringer, girder and truss. Generally not included were railroad bridges, bridges in private ownership and those that had been dismantled or permanently closed to vehicular traffic. There were exceptions, however, and several noteworthy vacated or privately owned bridges were included in the inventory.

The study was comprised of three elements - inventory, synthesis and evaluation. The inventory began with a compilation of a master list of bridges taken from a computer listing of all state and local structures maintained by NDOR. The computer file contains data relating to location, ownership and structural capacity but does not contain historical information beyond date of construction. Using records from the computer and NDOR's structural inventory and appraisal, the list was assembled and individual structures evaluated preliminarily for significance by structural type and date of construction. Fieldwork involving archival research and on-site documentation was then conducted for each bridge considered potentially eligible for NRHP from the preliminary assessment. The research methodology involved collection of primary and secondary source material to determine construction dates, designers, fabricators, contractors and the circumstances around the bridges' construction. This research entailed the use of NDOR and SHPO archival and inventory material, biennial reports of the State Engineer, *Nebraska Blue Print* and *Nebraska Monthly Highway Report*, records of the county boards of supervisors or commissioners, newspaper and magazine articles, original drawings, contracts, agreements and legislation, records from other government and archival sources and oral interviews.

The synthesis component of the study involved assimilating information collected from primary and secondary sources, and developing historic contexts relative to bridge and transportation trends in Nebraska. The final component was evaluation. Using the data compiled during the inventory, the bridges were evaluated individually within the contexts and compared for relative historical and/or technological significance, in accordance with the National Register Criteria. To aid with the assessment, a numerical rating system has been developed. Patterned after the previously developed systems of Virginia, Ohio and Colorado and fine-tuned during the course of the project, it assigns numerical values to the different aspects of significance as defined by the National Register. The rating divides into three essentially equal categories: level of documentation, technological significance and historic significance/integrity. The rating system is not intended to be a hardline arbiter of importance, but rather a means to quantify an array of factors which contribute to relative significance.

x See continuation sheet

After the winnowing process through application of the numerical criteria, several bridges emerged with similar - but not outstanding - significance. To address this, a three-tier system was employed to describe the bridges' potential for NRHP eligibility:

Category 1 (eligible): bridge which are unique or rare examples of technologically important types or have exceptional historical or representational value from larger bridge groups.

Category 2 (possibly eligible): bridges which are good early examples of their types or are notable variations from classical configurations; bridges which have some historical yet limited technological significance.

Category 3 (not eligible): bridges which are typical later examples of common structural types and which have minimal historical significance; bridges which have been substantially altered.

The distinction between Categories 1 and 2 became exceedingly fine at times when no clear cut examples emerged from a particular structural grouping. The cutoff between the possibly eligible bridges and those determined not eligible was more sharply defined. The numerical system ranges from 1 to 100, and the general cutoff guidelines were set at:

60 - 100 points	Category 1 (eligible)
35 - 59 points	Category 2 (possibly eligible)
1 - 34 points	Category 3 (not eligible)

The inventory findings were synthesized into a draft report, and the Category 1 and 2 bridges presented in March 1991 to an Advisory Committee. Made up of representatives from NDOR, the Nebraska State Historic Preservation Office and the Federal Highway Administration, among others, the Advisory Committee selected bridges as potentially eligible for NRHP on the basis of historical and/or technological significance. Thus, Category 2 (possibly eligible) has been eliminated, definitively classing all the bridges in the inventory into Category 1 (eligible) and Category 3 (not eligible). The bridges selected by the Advisory Committee as potentially eligible are listed by county below and are included in the accompanying National Register Registration Forms.

NEHBS No.	NDOR No.	Structure Name	Date	Spans	Description	Rating
Adams County						
AD04-716	none	Hastings Subway	1934	3- 42'	steel welded continuous deck girder	61
Antelope County						
AP04-204	C000202710P	Neligh Mill Bridge	1910	1-140'	pinned Pratt through truss	50
AP00-252	C000212505	Bridge	1911	1- 30'	pin/rigid Kingpost pony truss	55
AP00-3	C000221910	Elkhorn River Bridge	1883	1- 98'	bowstring through arch-truss	58
AP00-253	C000242110	Verdigris Creek Bridge	c1918	1- 30'	rigid Kingpost pony truss	45

NEHBS No.	NDOR No.	Structure Name	Date	Spans	Description	Rating
Boyd County						
BD00-224	C000808705	Ponca Creek Bridge	1904	1- 48'	pinned Pratt half-hip pony truss	43
Buffalo County						
BF00-64	C001034545	Sweetwater Mill Bridge	1909	1- 80'	pinned Pratt pony truss	43
BF00-2	S010 04736R	Kilgore Bridge	1915	3- 87'	pin/rigid Pratt pony truss	61
Burt County						
BT06-49	S075 13280	Tekamah City Bridge	1934	1- 48'	concrete rigid frame	51
Butler County						
BU00-83	C001200305P	Platte River Bridge	1891	1- 73'	pinned Warren through truss	52
BU00-84	C001200905	Big Blue River Bridge	1897-98	1- 40'	pinned Pratt truss leg bedstead	51
Cass County						
CC00-214	C001314125	Bridge	c1900	1- 50'	rigid Warren truss leg bedstead	40
CC00-215	S034 038208	Plattsmouth Bridge	1929	2-400'	rigid cantilevered through truss	66
Cedar County						
CD00-256	S081 21468	Meridian Bridge	1924	19-250'	rigid Pratt vertical-lift through truss	76
Cherry County						
CE00-223	C0E1603510P	Twin Bridge	1900	8- 16'	steel stringer	42
CE00-224	C0E1606105P	Borman Bridge	1916	1-130'	pinned Pratt through truss	48
CE00-225	C0E1637705P	Berry State Aid Bridge	1920-21	1-152'	rigid Pratt through truss	44
CE00-22	C001611605P	Bell Bridge	1903	1-147'	pinned Pratt through truss	54
CE00-226	C001611805	Brewer Bridge	1899	1-150'	pinned Pratt through truss	49
CE00-28	S020 19981	Bryan Bridge	1931-32	3-145'	rigid Pratt deck truss	71
CE00-227	S097 13350	Adamson Bridge	1916	6- 31'	timber stringer	47
Cheyenne County						
CN00-30	SS17A00030	Brownson Viaduct	1942	13-33'	timber stringer trestle	47
Clay County						
CY00-11	C001804915	Deering Bridge	1916	1- 50'	concrete filled spandrel arch	38
Cuming County						
CM00-58	C002024320	Rattlesnake Creek Bridge	1903	1- 60'	pinned Pratt half-hip pony truss	40
Custer County						
CU00-72	C002109305P	Mud Creek Bridge	c1911	1- 55'	rigid Warren pony truss	42
CU00-73	none	Sargent Bridge	1908	2-120'	pinned Pratt through truss	60

NEHBS No.	NDOR No.	Structure Name	Date	Spans	Description	Rating
Douglas County						
DO00-17	SL28B00163	Elkhorn River Bridge	1933-34	1-202'	rigid Pratt through truss	44
DO09:322-114	S00637025	Saddle Creek Underpass	1934	1- 50'	concrete rigid frame	42
DO09:97-1	S27519041	South Omaha Bridge	1933-35	2-525'	continuous Warren through truss	73
DO05-1	U082501805P	Main Street Bridge	1915	1- 28'	steel stringer	43
DO09:181-3	U182512605	O Street Viaduct	c1885	3-247'	pinned Whipple through truss	46
DO09:121-87	U1825Q5505	10th Street Viaduct	1890	31-75'	steel deck plate girder	61
DO09:192-20	U182505315	36th Street Viaduct	unk.	7-108'	rigid Warren pony truss	60
Fillmore County						
FM00-44	C003001125	Big Blue River Bridge	1918	1- 50'	concrete filled spandrel arch	34
Franklin County						
FR00-70	C003104705	Republican River Bridge	1911	3-120'	pinned Pratt through truss	59
FR00-72	S010 00548	Franklin Bridge	1932-35	3-100'	rigid Warren pony truss	60
Furnas County						
FN00-98	S047 01247	Cambridge State Aid Bridge	1914	5- 64'	concrete filled spandrel arch	68
Gage County						
GA00-43	C003404905	Mission Creek Bridge	1898	1- 42'	rigid Warren pony truss	43
GA00-44	C003411503	Bridge	1898	1- 30'	rigid Warren pony truss	43
GA00-45	C003412105	Big Indian Creek Bridge	1903	1- 60'	rigid Warren pony truss	39
GA00-46	C003413925	Bloody Run Bridge	1898	1- 30'	rigid Warren pony truss	43
GA00-2	none	DeWitt Mill Bridge	1887	1-150'	pinned Pratt through truss	60
GA00-47	none	Hoyt Street Bridge	c1870	1-140'	bowstring through arch-truss	66
Garden County						
GD00-118	C003500105P	Lisco State Aid Bridge	1927-28	8- 80'	rigid Pratt pony truss	58
GD00-119	C003505305P	Lewellen State Aid Bridge	1926-27	7-100'	rigid Pratt pony truss	58
Garfield County						
GF00-13	S011 09274	Burwell Bridge	1940-41	3-110'	steel cantilevered stringer	40
Hall County						
HL00-39	none	Nine Bridges Bridge	1913	3- 60'	pinned Pratt half-hip pony truss	64
Harlan County						
HN00-52	C004200905	Sappa Creek Bridge	1916	1- 62'	rigid Pratt pony truss	44
HN00-53	C004201705	Prairie Dog Creek Bridge	1913	1- 80'	rigid Camelback pony truss	47
HN00-54	C004211015	Turkey Creek Bridge	1899	1- 46'	pinned Pratt truss leg bedstead	46

NEHBS No.	NDOR No.	Structure Name	Date	Spans	Description	Rating
Hitchcock County						
HK00-78	C004402805P	Bridge	1908	1- 20'	concrete slab	38
Holt County						
HT00-261	C004521725	Grand Rapids State Aid Bridge	1931	7- 50'	transverse joist through girder	51
Howard County						
HW00-63	C004700305P	Boelus State Aid Bridge	1926-27	6- 60'	transverse joist through girder	53
HW00-76	S011 02748	Middle Loup River Bridge	1934	7-115'	steel continuous stringer	49
Jefferson County						
JF04-103	S015 00903	Fairbury Viaduct	1938-39	9-102'	steel cantilevered stringer	48
Johnson County						
JO00-64	C004913710	Keim Stone Arch Bridge	1916	1- 28'	stone arch	44
Keith County						
KH00-92	SL51B00074	Roscoe State Aid Bridge	1934-35	7- 86'	steel cantilevered stringer	44
Keya Paha County						
KP00-81	C005205705P	Lewis Bridge	1922	2- 60'	pinned Pratt pony truss	39
Knox County						
KX00-161	C005403805P	Verdigre Bridge	c1910	1-160'	pinned Parker through truss	38
KX00-313	C005413205	Gross State Aid Bridge	1918	1-180'	pinned Parker through truss	59
Lancaster County						
LC00-102	C005514020	Beal Slough Bridge	1937	1- 40'	concrete rigid frame	46
LC00-103	C005516205	Olive Branch Bridge	1897	1- 40'	pin/rigid Warren truss leg bedstead	53
LC00-100	SS55G00152	Bridge	1938	1- 25'	stone arch	23
LC13:C10-367	U142512130P	Tenth Street Viaduct	1910	19-121'	steel plate through girder	56
Lincoln County						
LN00-31	C005612930	Hershey State Aid Bridge	1927-28	9- 50'	steel transverse joist through girder	62
LN00-31	C005612935	Hershey State Aid Bridge	1927-28	5- 50'	steel transverse joist through girder	62
LN00-32	C005661710	Sutherland State Aid Bridge	1914-15	14-50'	concrete filled spandrel arch	72
Merrick County						
MK00-5	S014 07891	Central City State Aid Bridge	1919	16- 50'	concrete filled spandrel arch	61
Morrill County						
MO00-170	S092 07164	Broadwater Bridge	1924-25	7-100'	rigid Pratt pony truss	68

NEHBS No.	NDOR No.	Structure Name	Date	Spans	Description	Rating
Nemaha County						
NH00-85	S136 24018	Brownville Bridge	1939	2-420'	rigid Warren cantilever through truss	70
Nuckolls County						
NU00-729	C006510245	Stewart Bridge	1915	1- 45'	concrete filled spandrel arch	40
Otoe County						
OT00-85	C006601805P	Bridge	1912	1- 24'	concrete filled spandrel arch	38
OT00-86	C006602530	Little Nemaha River Bridge	1901	1- 65'	pinned Pratt pony truss	41
OT00-87	C006610270	Wolf Creek Bridge	1889	1- 76'	pinned Pratt through truss	48
OT00-88	C006616140	Wyoming Bridge	1878(?)	1- 80'	bowstring pony arch-truss	54
OT00-89	C006631625	Little Nemaha River Bridge	1874	1- 70'	bowstring pony arch-truss	62
OT00-90	C006633215	Bridge	1876(?)	1- 40'	bowstring pony arch-truss	43
Pawnee County						
PW00-98	C006702115	Bridge	c1900	1- 64'	pinned Pratt pony truss	40
PW00-42	C006733610P	Cincinnati Bridge	1879-80	1-119'	bowstring through arch-truss	67
Pierce County						
PC00-45	C007002215	Elkhorn River Bridge	c1910	1- 50'	pinned Pratt half-hip pony truss	31
PC00-46	C007013805	Willow Creek Bridge	1913	1- 34'	rigid lattice pony truss	48
PC00-47	C007014205	Elkhorn River Bridge	1914	1-120'	pinned Pratt through truss	38
Platte County						
PT00-68	S030 37773L	Columbus Loup River Bridge	1932-33	7-160'	rigid Parker through truss	68
Richardson County						
RH00-66	S159 01373	Rulo Bridge	1938	3-375'	rigid Pennsylvania through truss	65
Rock County						
RO00-72	C007522105	Carns State Aid Bridge	1912-13	5- 54'	concrete filled spandrel arch	64
Sarpy County						
SY00-189	C007712515	Big Papillion Creek Bridge	c1940	1- 80'	welded/bolted tied arch pony truss	40
Saunders County						
SD01-79	U0105F5605	Ashland Bridge	1936	1-100'	rigid polygonal Warren pony truss	50
Scotts Bluff County						
SF00-40	C007910325	Henry State Aid Bridge	1919	4- 67'	concrete filled spandrel arch	54
SF00-40	C007910330	Henry State Aid Bridge	1919	4- 67'	concrete filled spandrel arch	54
SF00-41	C007914525	Interstate Canal Bridge	c1915	1- 53'	rigid Pratt pony truss	44

NEHBS No.	NDOR No.	Structure Name	Date	Spans	Description	Rating
Sheridan County						
SH00-42	C008124905P	Colclesser Bridge	1888	1-166'	pinned Baltimore through truss	52
SH00-43	none	Loosveldt Bridge	1888	1-250'	pinned Baltimore through truss	59
Thurston County						
TS00-81	C008703105P	North Omaha Creek Bridge	c1905	1- 80'	pinned Pratt truss leg bedstead	45
Valley County						
VY00-26	C008833415	North Loup Bridge	1912	3-100'	pinned Pratt through	61
Washington County						
WN00-83	S030 45055	Abraham Lincoln Bridge	1928-29	3-333'	rigid Pennsylvania through truss	74
Webster County						
WT00-187	S281 00423	Red Cloud Bridge	1935	3-200'	rigid continuous Warren pony truss	69
York County						
YK11-51	S081 06204	York Subway	1938-39	1- 33'	concrete rigid frame	47
YK11-51	S081 06205	York Subway	1938-39	1- 33'	concrete rigid frame	47
YK11-51	S081 06208	York Subway	1938-39	1- 33'	concrete rigid frame	47

H. Major Bibliographical References

GOVERNMENT DOCUMENTS

Byrd, Tallamy, MacDonald and Lewis. "In-Depth Inspection, Condition Report and Structural Analysis for US-159, Rulo Bridge over Missouri River." Report prepared for Nebraska Department of Roads, November 1986, at Bridge Division, Nebraska Department of Roads, Lincoln, Nebraska.

Clay County, Nebraska. Proceedings of the Commissioners, 1911-12, located at Clay County Courthouse, Clay Center, Nebraska.

Harrington and Cortelyou, "Missouri River Bridge at Rulo." Microfilm copy, general plan and elevation, c. 1938, at Bridge Division, Nebraska Department of Roads, Lincoln, Nebraska.

"Lincoln Highway Registration Form," nomination to National Register of Historic Places, at Nebraska State Historical Society, Lincoln, Nebraska.

Nebraska Department of Public Works. *Thirteenth Biennial Report, 1919-20, Fourteenth Biennial Report, 1921-22, Fifteenth Biennial Report, 1923-24, Sixteenth Biennial Report, 1925-26, Seventeenth Biennial Report, 1927-28, Eighteenth Biennial Report, 1929-30,* and *Nineteenth Biennial Report, 1930-1931.*

________. *Monthly Report*, October 1919; April and June 1920; January, September and October 1921; February, June, July and October 1922.

Nebraska Department of Roads and Irrigation. *Twentieth Biennial Report, 1933-34, Twenty-First Biennial Report, 1935-36, Twenty-Second Biennial Report, 1937-38, Twenty-Third Biennial Report, 1939-40, Twenty-Fourth Biennial Report, 1941-42, Twenty-Fifth Biennial Report, 1943-44, Twenty-Sixth Biennial Report, 1945-1946.*

"Nebraska Historic Bridge Inventory." Prepared for the Nebraska Department of Roads, Lincoln, Nebraska, 1991.

Nebraska State Board of Irrigation. *First Biennial Report, 1895-96, Sixth Biennial Report, 1905-1906, Seventh Biennial Report, 1907-1908.*

Nebraska State Board of Irrigation, Highways and Drainage. *Ninth Biennial Report, 1910-1912, Tenth Biennial Report, 1912-1914, Eleventh Biennial Report, 1915-1916.*

Richardson County, Nebraska. Proceedings of the County Commissioners, 1906, located at Richardson County Courthouse, Falls City, Nebraska.

Ronis, Aivars G. "Nebraska State Aid Bridges, 1911-1936." Report prepared for Nebraska Department of Roads, 1978.

Schlitt, H.G. "Missouri River Progress Report," 20 September 1945. In files of the Bridge Department, Nebraska Department of Roads.

_x_ See continuation sheet

I. Form Prepared By

name/title	Charlene K. Roise, Principal		
organization	Fraserdesign and Hess, Roise and Company	date	24 July 1991
street & number	1269 Cleveland Avenue	telephone	303-669-7969
city or town	Loveland	state	Colorado zip code 80537

Cochran, Don. "Nebraska's Highways Past-Present-Future." *Nebraska Blue Print*, May 1950, pp. 186.

Cochran, Robert L. "Nebraska's Highway System." *Nebraska Blue Print*, October 1926, p. 9-10.

Condit, Carl. *American Building*. Chicago: University of Chicago Press, 1982.

"Construction of Pivot Pier, Interstate Bridge, Omaha, Neb." *Engineering News* 30 (23 November 1893): 410-412.

Darnell, Victor C. *A Directory of American Bridge-Building Companies*. Society for Industrial Archeology Occasional Publication, no. 4. Washington, D.C.: Society for Industrial Archeology, 1984.

Designs of Wrought Iron Bridges built by the Wrought Iron Bridge Co. of Canton, Ohio. Canton: Hartzell & Saxton, 1874.

Dick, Everett. *Conquering the Great American Desert*: Nebraska. Lincoln: Nebraska State Historical Society, 1975.

Dorsey, Guy P. "Pioneer Highways and City Pavements," Part 1. *Nebraska Blue Print*, March 1931, p. 5.

________. "Pioneer Highways and City Pavements," Part 2. *Nebraska Blue Print*, April 1931, p. 7.

"The Erection of the Omaha Bridge." *Engineering Record* 38 (27 August 1898): 268-269.

"The 520-ft. Swing Span, Interstate Bridge, Omaha, Neb." *Engineering News* 30 (7 December 1893): 448-449.

Gaddis, Vaughn. "Omaha Steel Works." *Nebraska Blue Print*, March 1947, p. 137.

"Harvey T. Ward is Called." *Tecumseh Chieftain*, 13 February 1926.

Hill, W.G. "The Lincoln Memorial Bridge." *Nebraska Blue Print*, March 1929, pp. 5-6.

Howard, E.E. "New Pier Design for Deep Overburden." *Engineering News-Record* 123 (23 November 1939): 687-688.

Jackson, Donald C. *Great American Bridges and Dams*. Washington, D.C.: Preservation Press, 1988.

Johnson, George "The Development of Nebraska Highways." *Nebraska Blue Print*, March 1922, p. 3.

Johnson, Ted. "A Discussion of the Transverse Joist Girder Bridge." *Nebraska Blue Print*, March 1927.

Kesner, H.J. "Some Recent Missouri River Bridges." *Nebraska Blue Print*, May 1929, pp. 9-10.

Lawson, Merlin P. et al. *Climatic Atlas of Nebraska*. Lincoln: University of Nebraska Press, 1977.

Lethem, John. *Historical and Descriptive Review of Omaha*. Omaha: n.p., 1892.

Levinger, Harold. "Omaha Steel." *Nebraska Blue Print*, October 1949, pp. 6.

Loutzenheizer, Don. "The Waubonsie Bridge." *Nebraska Blue Print*, December 1930, pp. 5.

Luten, Daniel B. "Defective Bridge Construction in the Prairie States." *Engineering News* 47 (17 April 1902): 304-305.

Mason, John G. and Josef Sorkin. "Bryan Bridge Adjudged Most Beautiful Bridge in Class C Competition." *Nebraska Blue Print*, February 1934, pp. 97-99.

Meyers, Harold B. "The Biggest Invisible Builder in the World." *Fortune*, April 1966, p. 147.

National Highway Users Conference. *Military Roads*: A Brief History of the Construction of Highways by the Military Establishment and a Gazetteer of the Military Roads in Continental United States. Washington, D.C.: n.p., 1935.

"The Nebraska City Bridge." *Engineering* 59 (11 January 1895): 43-45.

Nicolet, Justin. "Fifty-six Bridges to span New Power Canal." *Engineering News-Record* 117 (6 August 1936): 181-185.

Oliver, John W. *History of American Technology*. New York: Ronald Press, 1975.

Olson, James C. *History of Nebraska*. Lincoln: University of Nebraska Press, 1966.

Omaha City Directories, 1890-1894, located at Omaha Public Library.
"Omaha Firm Once Enviable." [Omaha] *World-Herald*, 8 April 1973.

"The Omaha Interstate Bridge." *Engineering Record* 47 (24 January 1903): 98-103.

Pen and Sunlight Sketches of Omaha and Environs. Chicago: Phoenix Publishing Co., 1892.

Price, Donald D. "Cement Plants and the Production of Portland Cement in Nebraska." *Nebraska Blue Print*, September 1931, pp. 11.

"Rebuilding the Missouri River Bridge of the Union Pacific R.R., Omaha, Nebraska." *Railway Review* 60 (10 February 1917): 191-194.

"Reconstruction of Union Pacific Railroad Bridge at Omaha." *Engineering* 103 (8 June 1917): 537-539.

"The Rulo Bridge." *Railroad and Engineering Journal* 61 (September 1887): 403-407.

Schubert, H.R. "The Steel Industry." In *A History of Technology*, pp. 53-71. Edited by Charles Singer, et al. New York and London: Oxford University Press, 1958.

Singleton, Jack. "Meeting Nebraska's Bridge Problems," Part 1. *Nebraska Blue Print*, October 1931, pp. 34.

Sorkin, Josef. "Economy through Continuity in Girder-Beam Bridges." *Engineering News-Record* 3 (26 October 1933): 496-498.

"Steel Plant in 75th Year." [Omaha] *Sunday World-Herald*, 2 October 1960.

Waddell, J.A.L. *Bridge Engineering*, vol. 1. New York: John Wiley & Sons, 1916.

Wakeley, Arthur C., ed. *Omaha: The Gate City and Douglas County, Nebraska*, vol. 2. Chicago: S.J. Clarke Publishing Co., 1917.

"Widening the Missouri River Highway Bridge at Omaha." *Engineering News-Record* 94 (18 June 1925): 1006-1010.

Wyman, Walker D. "Omaha: Frontier Depot and Prodigy of Council Bluffs." *Nebraska History Magazine* 17 (July-September 1936): 143-155.