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NAT. REGISTER OF HISTORIC PLACES
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United States Department of the Interior
National Park Service

National Register of Historic Places Multiple Property Documentation Form

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

X New Submission ___ Amended Submission

A. Name of Multiple Property Listing

Historic Roadway Bridges of North Dakota

B. Associated Historic Contexts

(Name each associated historic context, identifying theme, geographical area, and chronological period for each.)

Historical Patterns of North Dakota Bridge Construction, 1885-1946
Evolution of North Dakota Bridge Design and Engineering, 1885-1946

C. Form Prepared by

Name/Title: Mark Hufstetler / Historian
Organization: Renewable Technologies, Incorporated Date: December 10, 1996
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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 Archaeology and Historic Preservation. (___ See continuation sheet for additional comments.)

[signature]
Signature and title of certifying official James E. Sperry
State Historic Preservation Officer (North Dakota)
State or Federal agency and bureau

January 8, 1997
Date

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.

Edson H. Beall
Signature of the Keeper

2/27/97
Date of Action

E. Statement of Historic Contexts

A. Introduction

This Multiple Properties Documentation Form evaluates the historical and engineering significance of roadway bridges constructed within the boundaries of the State of North Dakota from 1885 to 1946. The category includes all bridges designed, wholly or in part, to carry a public roadway across a watercourse or other travel barrier, as well as structures designed to carry railroads, canals, or other linear features over or under public roadways. Bridges with a historic use unrelated to the construction or use of public roadways are excluded from this nomination. While the construction of roadway bridges in North Dakota probably dates to the earliest days of permanent Euro-American settlement in the region, no bridges predating 1885 are believed to survive in the state. The time period covered by this nomination therefore begins in 1885, and extends to 1946, the current fifty-year cutoff date for National Register of Historic Places eligibility. This document includes contextual information for evaluating both the history and technology of North Dakota bridges constructed during this period. An appendix at the end of Section E defines common technical terms relating to bridge engineering and design.

B. Geographical Background

Bridges everywhere are constructed to counter obstacles to transportation, whether natural or human-made. In predominately rural North Dakota, that obstacle is typically a watercourse, a ravine, or other natural feature. Consequently, North Dakota's geography and geological development are important elements governing the design and distribution of the state's historic bridges.

During the Paleozoic and Mesozoic eras, the area now described as North Dakota was covered by a succession of seas and rivers, which left layers of limestone, sandstone, and shale. Swamp vegetation and more water coverage during the Cenozoic Age created lignite, clay, and bentonite. During the Ice Age, glaciers swept all but the southwestern portion of the state, redirecting the Missouri River from its prehistoric route north towards Hudson Bay to its current path to the Gulf of Mexico. The Red River owes its broad valley to the melting glaciers which created Lake Agassiz, a giant body of water which covered over 110,000 square miles.

These geologic actions left North Dakota with a variety of geographic conditions affecting bridge construction.

A thick layer of silt from the ancient lake's bottom is responsible for the Red River Valley's fruitfulness, but the unstable banks of the Red River pose a challenge to bridge designers. The river flows slowly northward, dropping only about one foot per mile, and its banks are in a continuous state of flux. In addition, the sluggish flow allowed massive ice jams to form in the spring and wreak havoc with flooding and bridge bashing. Together the Red River and the Bois de Sioux River, which flows into the Red from Lake Traverse to the south, define the state's eastern border, and they presented an unavoidable obstacle to passage for early travelers. As time passed, the rivers and their many tributaries were to offer many challenges and opportunities for bridge builders.

Rising to the west of the Red River Valley is the Drift Prairie, a region of rolling hills and fertile soil formed from glacial deposits of finely ground rock, sand, and gravel -- handy materials for road construction. Here the headwaters of the James and Sheyenne Rivers, as well as a number of lakes, required bridging as the state developed.

The Missouri River flows for 410 miles through North Dakota. It is a major component of the state's third important geological area, the Missouri Plateau, which extends west to the Montana border. Covering about half of the state, the plateau's eastern rim is defined by the rough hills of the Altamont Moraine. West of the river is "the Slope," its terrain inclined as the name suggests, bisected by ravines up to 200-feet deep running primarily in a north-south direction. Finally, in the state's southwest corner in an area untouched by glacial activity, are the unique buttes of the Badlands edging the Little Missouri River.

C. Context 1: Historical Patterns of North Dakota Bridge Construction, 1885-1946

1. *Historical background*

<u>a. Early Settlement and travel patterns</u>: The first Euro-American visitors to the future state of North Dakota arrived during the eighteenth century. In 1738, Pierre Gaultier de Varennes, Sieur de la Verendrye, a fur trader and explorer, became the first Euro-American known to visit the region. David Thompson led a survey expedition to the area in 1797; his work was the basis for the later establishment of the north border of the

western United States. Thompson was soon followed by representatives of several fur trading companies, establishing posts throughout the area. The first attempt at permanent settlement in future North Dakota was the Selkirk colony of 1812, at present-day Pembina. Military forts brought more people to the region, particularly during the 1860s and 1870s, when local Indians became disgruntled by the influx of pioneers and gold prospectors. The military constructed the first rudimentary network of roads in what was to become North Dakota, connecting the various forts with supply centers. Undoubtedly, these roads also included the earliest bridges built in the state, although most of the roads were laid out to take advantage of fords or crossings.[1]

The area's major rivers, although an impediment to land travel, served as a mode of transportation in their own right. The Red River attracted investors from Minneapolis and St. Paul, who arranged for a steamer to be launched there in 1859. The vessel proved the viability of commercial travel on the Red River by means of a successful voyage downriver to Fort Gary (now Winnipeg). Although steamboats stimulated the growth of river trade centers, such as Grand Forks and Fargo, they ultimately gave way to railroads. By 1880, most of the larger steamboats had been taken out of service on the Red.[2]

On the Missouri, the steamboat "Yellowstone" joined the canoes and crude rafts of fur traders and explorers in 1832, when it ventured upstream to Fort Union (at the present North Dakota-Montana border). This route was continued and expanded in subsequent years. Steamboats carried passengers, provisions, and the produce of the newly broken fields on the plains. After the Northern Pacific Railroad reached Bismarck in 1873, traffic from the east could reach Bismarck by rail and then travel upriver on the boats. The railroad bridged the Missouri in 1882 (the first crossing on the upper river), portending the demise of the steamboat, although some commercial river traffic continued into the 1930s.[3]

The influence of steamboats on the settlement of North Dakota was necessarily limited. Not only was river traffic seasonal, but steamboat travel was unreliable, given fluctuating water levels, potential conflicts with Native Americans, shifting sandbars, and other obstructions. More importantly, much of Dakota was simply inaccessible to riverboats. It remained for the railroads to bring intensive Euro-American settlement to vast reaches of Dakota Territory.

b. Railway Development in North Dakota: The arrival of the railroads in Dakota Territory dramatically altered travel patterns and methods in the region, increased the pace of Euro-American settlement, and resulted in the construction of many of North Dakota's early bridges. North Dakota's first rail lines began as routes leading from the developing Minneapolis and Lake Superior areas to the fertile Red River Valley. One such line, the Northern Pacific (NP), became North Dakota's first railroad in 1872, building west from Fargo as part of an ambitious plan to link Duluth and the Pacific coast by rail. The line quickly built westward to Bismarck, but the Panic of 1873 temporarily halted the railroad's expansion and drove it to bankruptcy. The Panic stalled most other railroad construction projects as well, and caused many of the companies to suffer financial ruin.[4]

Railroad construction in Dakota began to resume in the late 1870s. The Northern Pacific was again building westward by 1879, crossing the Missouri at Bismarck and completing its line to Puget Sound in 1883. The railroad's iron truss bridge across the Missouri (completed 1882) was the first Missouri River bridge in northern Dakota Territory. In the years that followed, the NP constructed numerous branch lines serving the eastern and southern sections of North Dakota; this track network made it the predominant transportation force in southern North Dakota for decades.[5]

Soon after, an equally powerful railroad began development efforts in the northern reaches of the territory. This corporation was the St. Paul, Minneapolis & Manitoba Railway, the corporate predecessor of the Great Northern (GN). The railroad was a principal endeavor of James J. Hill, a Minnesota capitalist who is credited with being a central figure in the settlement of North Dakota. Beginning in the early 1880s Hill's railroad began constructing a network of lines in the Red River Valley, and had completed an east-west line across the territory by 1887. Later, the GN built a network of branch lines in the state rivaling that of the NP, making the Great Northern as powerful a force in the northern portion of North Dakota as the NP was in the southern half of the state.

Other railroads also built into North Dakota between the 1880s and the 1910s. The Minneapolis, St. Paul & Sault Ste. Marie (the "Soo Line") built a fairly extensive network, which operated three east-west lines across the eastern half of the state, as well as a line to Canada which traversed North Dakota diagonally. Other railroads in the state included the Chicago, Milwaukee, & St. Paul (the "Milwaukee Road"), the Chicago & North Western, and an in-state short line named the Midland Continental. As early as 1890, North Dakota had four times more trackage per 10,000 population than the national average, and the bulk of the state's rail lines were yet to be built.[6]

In addition to providing basic transportation services for North Dakota, the railroads actively encouraged town settlement and economic development in the areas they served. Rail transportation stimulated large-scale agricultural growth by increasing the accessibility of both farmland and markets. Railroad subsidiaries and promotion departments sought to create new traffic by enticing farmers, merchants, and manufacturers to settle along their tracks. These new settlements depended on the railroads to connect them to major wholesale and manufacturing centers; similarly, they depended on networks of rural roads in the surrounding countryside to link individual farmers to the railroads and the communities they created.

Roads and railroads functioned together in an integrated statewide transportation system of trunks, major branches, and smaller feeders. The efficient transportation provided by railroad trunk and branch lines helped stimulate the improvement of the vehicular roads (and their accompanying bridges) which served the railroad lines. This relationship between railroads and vehicular roads continued into the twentieth century as railroad companies supported the "Good Roads" movement (discussed later in this document), believing it would bring more traffic to their stations and freight yards.[7]

The railroads themselves built numerous bridges in North Dakota, including some of the largest and most impressive spans in the state. While most railway bridges are beyond the scope of this project, the railroads were also a major influence on the evolution of highway bridge construction in North Dakota. Railroads provided the network for economically transporting steel for bridges from industrial centers to the state. Railroad bridge engineers also pioneered the designs for bridges capable of carrying heavy loads moving at high speeds. They built many of the first large iron and steel bridges in the state; in doing so they may have indirectly helped inspire the later construction of similar roadway structures.

The railroad companies did erect some highway bridges, as well, primarily overpasses and underpasses for roads and streets crossing rail lines (such structures are commonly called "grade separations"). Occasionally, rural county roads crossed rail lines on railroad-built wooden roadway trestles. Railways periodically built roadway bridges when a new railroad line crossed a roadway alignment on either a fill or a cut, or in response to local pressure from city or county governments. For example, in 1912 Mercer County's commissioners formally noted that a grade crossing near Stanton was "such that the view to the north is practically wholly obstructed. The approach is very sandy and teams and vehicles are liable to get stuck." The commissioners requested that the Missouri River Railway Company (an NP subsidiary) build a railroad bridge over the highway. The railroad did so, and in turn, the county revised the highway alignment leading to the new bridge.[8] Despite instances such as this, railroad-constructed highway bridges were relatively uncommon in North Dakota; it was not until the advent of state-sponsored grade separation projects in the 1920s and 1930s that numerous bridges appeared carrying railroads over or under highways.

Railroad bridges also occasionally received ad hoc use as vehicular crossings, especially during the early days of roadway construction. Most vehicular uses of railroad bridges were temporary and informal, unsanctioned by either railroad or governmental authorities. At least one railroad bridge, though -- the Fairview lift span in McKenzie County -- saw regular vehicular use for decades and had planking placed between the rails for automobile travel.[9]

c. Early Roads and Bridges: The earliest methods of travel in what was to become North Dakota--foot, horse, dog sled, and travois--were not reliant on a network of maintained roadways. Nonetheless, they still often utilized long-established, vaguely defined travel routes, the earliest precursors of a formalized roadway system. By the nineteenth century, however, the procedures and mechanisms of travel began to evolve with increasing rapidity. The two-wheeled Red River cart was widely used during the early 1800s, and in 1843 the American Fur Company established regular oxcart service between St. Paul and Pembina. Commercial stage coach lines followed in 1859. For the most part, these early carriers utilized only primitive, unmaintained roadways which were defined through continuity of use rather than engineered construction. Where the roadways crossed major rivers, entrepreneurs often set up ferries to ease the passage.[10]

Most major river crossings in North Dakota were served by ferries well before the arrival of long-span bridges in the state. Numerous privately-operated ferries are known to have existed on both the Missouri and Red Rivers during the late nineteenth and early twentieth centuries; they may have existed on other watercourses, as well. Ferry crossings served an important need in frontier North Dakota, but their long-term usefulness was limited by seasonal considerations, scattered reliability problems, and concerns about tolls. Most of the state's ferry operations had vanished by the early twentieth century as North Dakota's road and bridge network matured, but scattered ferries remained in use throughout the historic period. None remain in use today.

With few exceptions, North Dakota's first wagon and pedestrian bridges were constructed by local residents. These structures were normally built without government involvement, resulting in primitive, informal designs. Most were built of timber with relatively short spans, and were designed to carry local traffic over creeks, marshes, or other small natural barriers. Rarely did these bridges last more than a few years before either collapsing under a heavy load or washing away in a spring flood. No documentation exists concerning the first formal bridge to be constructed in North Dakota, but it was almost certainly built under these circumstances, and it probably vanished well over a century ago.

By the early 1880s, many city, county, and township governments were being established in portions of northern Dakota territory; simultaneously, the first network of formally designated roadways began to evolve. These factors helped underscore the need for larger, professionally designed bridges in the area, while also providing the varied organizational and funding mechanisms necessary for their construction. An informal hierarchy developed in many counties, with townships generally responsible for smaller wooden bridges and the cities and counties undertaking the construction of larger spans. By 1885, cities and counties throughout the Red River Valley were constructing substantial wood, iron, and combination bridges. While locally built wooden bridges continued to be used for small crossings, the ferry crossings of earlier years began to be replaced by large bridges constructed by experienced contractors. (The location and date of the first iron bridge in North Dakota is not known, but several existed in the Red River Valley by the mid-1880s. None of these pre-1885 bridges survive.)

The evolution of the Red River crossing at Fargo-Moorhead illustrates the often arduous process of securing a permanent bridge. Two ferries originally carried traffic across the river. Wagons took advantage of the Northern Pacific Railroad bridge when it opened in June of 1872, apparently managing to coexist with the train schedule. A safer and more convenient alternative became available in 1874, when Moorhead funded a wooden-trestle wagon bridge across the Red River. The latter bridge was not ideal, however, since it had to be taken down every spring to avoid being demolished when the ice went out. Finally in 1884, two permanent swing-span truss bridges were constructed between the cities.[11] They were among a very few moveable bridges ever constructed for North Dakota roadways; no swing or lift roadway bridges survive in the state today.

The Fargo-Moorhead bridges, in common with nearly all of North Dakota's nineteenth-century road and bridge projects, were constructed under the aegis of a local governmental body. This circumstance was a direct result of actions by both the Dakota territorial government and the North Dakota state government which heavily restricted state participation in highway improvement projects. Among the earliest legislation governing road construction in the North Dakota region was a law generated by the territorial legislature in 1885, which authorized the issuance of bonds of up to $5,000 for individual highway construction; the legislature would consider issuing such bonds following the receipt of a road petition signed by two-thirds of the voters in the area. This mechanism probably proved too restrictive to generate significant territorial highway projects, but a very similar provision appeared in North Dakota's 1889 state constitution. Section 185 of the document describes a number of restrictions on state financing, concluding with the statement: "Nor shall the state engage in any work of internal improvement unless authorized by a two-thirds vote of the people."[12]

The restrictions imposed by North Dakota's constitution effectively barred the state from any financial participation in road development, thus placing the full burden on the counties and townships. To facilitate roadway construction by local governments, both counties and townships were soon granted authority to issue bonds to pay for road and bridge work. In 1893, counties were authorized to tax property to raise money for a county bridge fund, and in 1895, counties with over 5000 residents could institute a poll tax of $1.50 for funding roads. The population minimum was lowered to 2000 in 1905. Those affected by the poll tax -- males between the ages of 21 and 50 -- could pay the tax outright or offer a day's labor on road construction in exchange.[13]

Like roads, requests for bridges were brought forth by petition. Chapter 38 of the laws of the first session of the North Dakota Legislature in 1890 stated that "whenever a majority of the freeholders of a civil township or a majority of the freeholders living within a radius of three miles of the proposed location, shall petition the board of county commissioners for a bridge" costing over $100, then the Commissioners must explore the need for such a bridge. If approved, the Board "shall proceed to advertise in the official paper in the county, for a period of thirty days, the plans and specifications of the proposed bridge, asking for sealed bids . . . and shall award the contract to the lowest responsible bidder." The cost was to be paid from the county bridge fund. Another major step for highway improvement occurred in 1895, when the state legislature ruled that a 66-foot-wide strip along all section lines was to be set aside for public roads; this encouraged the development of a "grid" of rural roads one mile apart, extending across much of North Dakota.[14]

(As with most midwestern and western states, North Dakota land was surveyed by the federal government using a system of Townships, Ranges, and Sections. The "section," a unit of land one mile square, became a basis for land ownership subdivision, and consequently, near-standard locations for rural roadways.) All these acts encouraged the construction of improved roads and bridges, but placed the responsibility for such projects squarely on the shoulders of North Dakota's county and township governments. Consequently, the county-sponsored construction of roads and bridges became more and more common. By the mid-1880s, several counties in eastern North Dakota (including Traill, Cass, Grand Forks, and Richland) had formal, well-established road and bridge construction programs; these activities had spread to most of the state's other counties by the end of the nineteenth century.

2. The era of County-sponsored bridge construction (c. 1885-c. 1920)

a. Out-of-state bridge builders in North Dakota: As North Dakota's counties proceeded to construct more, larger, and more complex bridges, county commissioners found themselves needing to seek the services of individuals with expertise in engineering and construction. Although they occasionally retained professional civil engineers, more often, the commissioners utilized plans and specifications which were supplied by the bridge builders bidding for bridge construction contracts. Consequently, these private bridge contractors quickly assumed a significant level of influence over both the design and the methods of constructing North Dakota's larger bridges. This level of influence increased as more and more of North Dakota's bridge construction began to be handled by contracting firms. Initially, these firms were established bridge companies from out-of-state who expanded their business activities by seeking contracts in Dakota Territory. These firms thoroughly dominated the first two decades of large-scale highway bridge construction in North Dakota.

A number of out-of-state bridge builders solicited work in North Dakota during the last two decades of the nineteenth century. The most active of these contractors came from Minneapolis, which had several direct rail routes to North Dakota by the 1880s. The Minneapolis bridge builders included C.P. Jones, S.M. Hewett, and the Gillette-Herzog Manufacturing Company. A few firms from other states, such as the Wrought Iron Bridge Company of Canton, Ohio, and the Milwaukee Bridge and Iron Works and the Wisconsin Bridge and Iron Company, both of Milwaukee, Wisconsin, also competed successfully for bridge contracts, particulary in the eastern part of the state.[15]

Many of these nineteenth-century bridge builders also fabricated the bridges they constructed. Companies owned by the Gillette family of Minneapolis were prominent among the suppliers of bridge materials to North Dakota and representative of them. The Gillette-Herzog Manufacturing Company had its origins in the 1870s as the Northwestern Fence Works, a small, Minneapolis-based, wrought-iron fabricator owned by Phillip Herzog. In the mid-1880s, the firm expanded to produce ironwork for banks, prisons, and jails, hiring a civil engineer named Lewis S. Gillette, who had worked for James J. Hill's St. Paul, Minneapolis and Manitoba Railroad, as well as for the St. Anthony Falls Water Power Company. By the late 1880s, Gillette was president of the company, his brother George was secretary-treasurer, and a new bridge department was established with Alexander Y. Bayne as manager. The company also reorganized as the Gillette-Herzog Manufacturing Company. Bayne, who during the late 1880s had operated his own regional, Minneapolis-based, bridge-building company, quickly established Gillette-Herzog as one of the active bidders for bridge projects throughout Minnesota, North and South Dakota, and Montana. In 1900, J.P. Morgan formed the giant American Bridge Company by absorbing 24 of the largest bridge fabricators in the United States, including Gillette-Herzog.[16]

Shortly after the Gillettes sold their company to Morgan, they started another, the Minneapolis Steel and Machinery Company, which became a major supplier of bridge steel throughout the Upper Midwest. By 1903, the company's plant in Minneapolis covered about two-and-one-half blocks, and within a few years employed 1,200 workers. Aiming to serve local governments which could not afford to employ a professional engineer, Minneapolis Steel and Machinery made available standard sets of specifications developed especially to address the greater stresses being placed on rural agricultural bridges in the region by heavy steam traction engines.[17] Fabricators like the Minneapolis Steel and Machinery Company also prepared steel for the many bridge companies that appeared around the turn-of-the-century and specialized in the construction of steel bridges. These fabricators would have also supplied bridge steel to counties, such as Grand Forks County in North Dakota, which awarded separate contracts for steel and for bridge erection from 1899 until 1904.[18]

A number of iron and steel truss bridges constructed by these out-of-state firms survive in North Dakota in 1996. Among the best examples are the Caledonia Bridge (32TR695)and the Goose River Bridge (32TR693), built by the Wrought Iron Bridge Company; a small private bridge in Cavalier (32PB87), built by Gillette Herzog; and the Cedar Creek Bridge (32AD50), built by Twin City Bridge.

b. North Dakota's Bridge Builders: With only occasional exceptions, out-of-state bridge contractors thoroughly dominated the construction of North Dakota's major nineteenth-century highway bridges. By the late 1890s, however, a small nucleus of in-state bridge construction firms had developed; they were later joined by a number of other North Dakota individuals and companies. Two of these bridge businesses expanded and prospered throughout the early twentieth century and beyond, providing an unusually strong local influence in the construction patterns of North Dakota's highway bridges.

The most successful of the North Dakota bridge firms was the Fargo Bridge and Iron Company. As was often true for regional bridge-building companies, Fargo Bridge and Iron began as the dream of an ambitious agent of another bridge company. In this case, the agent was Francis E. Dibley (1860-1910), a Milwaukee native who served as the Fargo representative of the Wisconsin Bridge and Iron Company beginning in 1889. In 1898, Dibley and W.H. Robinson of Mayville formed the bridge-building partnership of Dibley and Robinson, and actively began soliciting county bridge contracts throughout eastern North Dakota. By 1901, Dibley and Robinson had completed several bridge projects in at least four North Dakota counties. Only one of Dibley and Robinson's vehicular bridges is known to survive -- a pin-connected Pratt through truss constructed by the firm in 1900 near Blanchard in Traill County (32TR698).[19]

In 1901, Robinson apparently left the company, and Dibley reorganized the firm into the Fargo Bridge and Iron Company. Fargo Bridge and Iron met with resounding success during the 1902 construction season: that first year, it received contracts from at least 10 North Dakota counties, resulting in the construction of over three dozen new bridges. This was a level of dominance never achieved in North Dakota by any other bridge contractor.

Fargo Bridge and Iron continued to dominate highway bridge construction in North Dakota through the 1920s. The company made little effort to solicit work in the state's most westerly counties, but many of the counties in central and eastern North Dakota became the near-exclusive domain of Fargo Bridge and Iron. In Foster County, for example, Fargo Bridge and Iron received every bridge contract advertised by the county between 1902 and 1930, despite the fact that most of the county's bridge contracts were ostensibly awarded through a competitive bidding process. Similar situations existed in at least a dozen other North Dakota counties.[20] Today, over fifty early truss bridges constructed by Fargo Bridge and Iron are known to survive throughout the state. One of the best remaining examples of their early products is the New Rockford Bridge (32ED223) in Eddy County.

The state's second-largest bridge contracting firm was also located in Fargo. John R. Jardine (1846-1906) was a Cass County homesteader who formed a small bridge-building company in 1882, primarily to construct bridges for the new Fargo and Southwestern Railroad. Jardine initially built only wooden bridges; in 1898, however, he demonstrated his ability to construct steel bridges by fabricating and building a steel bridge in Cass County. This structure, built under the corporate name of the North Dakota Steel Bridge Company, is the only bridge known to have been built of steel members fabricated within the state of North Dakota. (The steel itself, however, still came from out-of-state.)[21] Jardine followed this initial project with other steel bridges in the state's Red River Valley.

When Jardine died in 1906, control of the business passed to his son, John A. Jardine. That year, the younger Jardine formed a partnership with M.S. Anderson, a Hillsboro, North Dakota resident who had completed earlier bridge contracts for Traill County. Jardine and Anderson Bridge Contractors continued in business until 1919, building a substantial number of bridges in the Red River Valley. The partnership dissolved in 1919, with Anderson resuming his contract work for Traill County and the parent firm continuing in Fargo as the Jardine Bridge Company. The founder's grandson, John Bishop Jardine, joined the company in 1937, after graduating with a degree in engineering from the University of North Dakota. The Jardine Bridge Company operated until shortly after John B.'s death in 1963, making it one of the longest-lived bridge companies in the United States.[22] Several early Jardine and Anderson bridges survive in Grand Forks and Traill Counties, including the Norway Bridge (32TR684).

The bridges erected by the Fargo Bridge and Iron Company and Jardine and Anderson utilized standard designs developed and proven elsewhere. In addition, they employed structural members fabricated at out-of-state foundries. (The absence of a large industrial base in North Dakota meant that the state's foundries and machine shops were mainly small local enterprises specializing in farm tools and small castings.)[23] The significance of these two companies, then, comes not from locally generated materials or engineering techniques, but from the high level of local control they maintained in a market usually dominated by out-of-state companies.

In addition to the two large Fargo-based bridge companies, a number of smaller, local builders also successfully competed for North Dakota bridge contracts. While a few of these firms were large enough to actively solicit bridge contracts in a number of North Dakota counties, most were small general contracting firms which performed bridge work in their home county as one segment of a broader business. In all, there may have been several dozen such contractors, although most built only small timber bridges or completed routine bridge maintenance and repair contracts. Most performed a significant level of work only in a single North Dakota county.

Among the busier of these contractors were George W. Kemper of Minot, George Nollman, Sr. of Grafton, and T.M. Swingen of Cooperstown, all of whom sought bids in several North Dakota counties during the early twentieth century. Swingen also solicited highway grading contracts, a practice common for many of these firms by the 1920s and 1930s. In the southern portion of the state, the Hettinger Bridge Company and the Linton Bridge Company operated out of their namesake communities. J.H. Pifer and A.F. Turner of Grand Forks are representative of the many smaller bridge builders. Pifer also worked as a railroad ice contractor (supplying ice for use in insulated railroad cars carrying perishables) and Turner became sheriff of Grand Forks County and police chief of the City of Grand Forks.[24]

Relatively few of North Dakota's early twentieth-century bridge contractors remained active throughout the 1930s, 1940s, and beyond. This was probably due, at least in part, to the changing patterns of the construction industry as a whole, which began to favor larger, more diversified construction and engineering firms. One exception to this trend was the Rue Construction Company of Bismarck, which was founded by Milton L. Rue, Sr. in 1924. The Rue firm was reportedly engaged in the highway and bridge construction business longer than any other North Dakota contractor, and was particularly active during the post-World War II years. Rue Construction completed an estimated 750 bridges, many of which were built as part of North Dakota's Interstate Highway system. Milton Rue (1899-1968) was also active in North Dakota politics, earning the appellation "Mr. Republican."[25]

<u>c. Patterns of Contract Awards</u>: A noteworthy pattern of bridge construction was established in North Dakota during the early twentieth century. When counties in North Dakota, as well as South Dakota, Nebraska, Minnesota, and Montana, first began awarding contracts for bridge construction, they advertised for bids and awarded contracts on an individual basis, often to a number of different companies at the same letting. By the late 1890s, however, some counties began routinely awarding successive contracts to a particular company. Shortly after the

turn of the century, the practice of awarding annual contracts became commonplace among counties in South Dakota and Nebraska. Typically, a county would advertise for bids on a lineal foot basis for several different bridge types based on designs supplied by a bridge company, most often the company holding the current year's contract. In 1911, the South Dakota legislature passed a law requiring that counties award annual contracts for bridge construction. North Dakota's legislature never enacted comparable legislation, but a few North Dakota counties adopted the system of annual bridge contracts during the early twentieth century. Among the counties which awarded annual bridge contracts were Traill, Ward, and Towner.

In the cases where a single company received contracts from a county for several years, and where companies getting this repeat business tended to be different from one county to the next, it might at first appear that there had developed a mutually beneficial relationship between the county commissioners and the bridge builders. More probably, however, the "coincidence" was not chance at all but rather a form of collusion called "bridge pooling," a common practice throughout the United States in the late-nineteenth and the early-twentieth centuries. Within a bridge pool, the companies agreed to divide a region, assigning particular counties in various states to specific bridge companies. Whenever a bridge construction project was advertised, agents for each of the companies would meet near the site and discuss the cost of the project. If members of the pool could agree, they would permit the company in whose territory the bridge was to be built to submit the low bid, allowing for a comfortable profit, and the others would submit higher bids. At the conclusion of the project, the successful bidder would disperse a portion of the profit to the other companies in the pool. Nineteenth-century companies bidding in North Dakota, such as the Wrought Iron Bridge Company, S.M. Hewett, and the Gillette-Herzog Manufacturing Company, are known to have participated in bridge pools.[26]

Circumstantial evidence strongly suggests that collusion among bridge builders did occur in North Dakota, even between the two major in-state companies. Perhaps the best evidence may be found in the neighboring counties of Walsh and Grand Forks. In 1910, Jardine and Anderson won its first annual contract in Grand Forks County. The firm was awarded the county's annual contract through the rest of the decade, even though one of the bidders in every year but 1914 was Fargo Bridge and Iron. Meanwhile, in adjacent Walsh County, Dibley and Robinson, who later became the Fargo Bridge and Iron Company, won their first contract in 1900. Every year, the Walsh County Commissioners put a list of bridges up for bid, and every year through 1915, approximately half of the bridge jobs were awarded to Fargo Bridge and Iron and half were awarded to the Grafton firm of Nollman and Lewis. From 1915 until 1920, Fargo Bridge and Iron won almost all contracts, although Nollman and Lewis did receive some work. John Jardine of the firm of Jardine and Anderson first bid in Walsh County in 1901, bid intermittently until 1913, and then bid every year until the end of that decade. Thus in the decade 1910-1920, the two Fargo bridge-building companies were "bidding" against each other year after year in neighboring counties, but Jardine and Anderson was successful in Grand Forks County every year to the exclusion of Fargo Bridge and Iron, while Fargo Bridge and Iron was successful in Walsh County every year to the exclusion of Jardine and Anderson. If the bidding had indeed been honest, it seems likely that each company would at least occasionally have received contracts in the other county.[27]

The likelihood of collusion also appears in several other North Dakota counties, where contracts were awarded to the same company or their successors over many years. In Barnes County, the Gillette-Herzog Manufacturing Company of Minneapolis and later its agent, A.Y. Bayne, appear to have built all of the bridges from at least 1894 until 1913. F.E. Dibley, either acting as agent for the Wisconsin Bridge Company or as an owner of Dibley and Robinson and its successor, Fargo Bridge and Iron, built all of the bridges in McHenry County from 1896 until at least 1922. In Stark County, A.Y. Bayne received the first annual contract in 1911, and he maintained his position (later under the name of the Minneapolis Bridge Company) until the 1920s.[28]

On the other hand, collusion was not universal. McKenzie and Ramsey counties awarded contracts to several bridge-building companies over a long period of years, and no single company dominated bridge construction there.[29] It should also be noted that the existence of bridge-pooling in North Dakota is supported only by circumstantial evidence, and that in some instances other undetermined factors may have been responsible for observed patterns of contract awards.

2. The era of state-sponsored bridges and roads (c. 1913-1946)

a. The evolution of the State Highway Commission and State Engineer's Office: The first automobile reported in North Dakota made its appearance on the streets of Grand Forks on June 28, 1897. The state's automobile population grew rapidly during the early years of the twentieth century. By 1910, there were 800 Fords (to say nothing of other models) in the state; within nine years, the introduction of the Model T increased the Ford population to 42,801. In 1914, North Dakota stood fifth in the nation in the number of cars per capita, preceded only by California, the District of Columbia, Iowa, and South Dakota. Nine years later, the state dropped to eighth in the ranking with 80,000 cars, still an impressive one-car-for-every-nine North Dakotans.[30] Nevertheless, the widespread use of autos in North Dakota did not lead to rapid road improvement. Between 1904 and 1914, while North Dakota was among the nation's leaders in cars per capita, the state actually dropped from forty-third to last place among the forty-eight states in the percentage of its roads that were improved.[31]

It quickly became apparent, though, that the automobile was not just a passing fad, and governing bodies had to face the problems that came along with it. The legislature passed a bill in 1905 regulating speed limits, as well as "An Act for the Destruction of All Weeds on All Graded or Cultivated Highways," intended to improve the suitability of roads for automobile travel.

In 1905, the State Engineer's Office was created to assist with irrigation work; the engineer soon assumed responsibility for oversight of roads and bridges. In 1909, the legislature established a "Good Roads Experiment Station" at Bismarck to explore "the most practical and economical construction and maintenance of public roads and highways in this state." The Board of Trustees of Public Property was created to supervise construction of all highways. The State Engineer was directed to make surveys and plans for roads and bridges, and supervise construction and maintenance. The warden of the State Penitentiary was to make available convict labor "if not otherwise employed." This legislation apparently resulted in only very minimal road construction work, which took place in the Bismarck area.[32]

In 1911, the state began to require automobile licenses. After subtracting administrative expenses, the net proceeds from the $3.00 licensing fee were turned over to counties for "special road maintenance funds." Registration was handled by the Secretary of State. At the same time, a bill was introduced requiring counties to appoint a Superintendent of Highways to oversee construction and maintenance of roads. The House made this provision optional and, as a result, only Billings, Burleigh, Dickey, Griggs, and Stark counties established such positions.[33]

By this time, at least some North Dakota counties were beginning to occasionally solicit the expertise of the State Engineer's Office. In a report issued in 1912, State Engineer T.R. Atkinson mentioned that his office had responded to a request from the commissioners of Billings County for plans for "a steel bridge over the Little Missouri River at Marmarth." An assistant from the State Engineer's Office made "the necessary surveys and soundings and complete plans and specifications for a steel bridge and for a reinforced concrete bridge."[34] Although a higher-than-expected price tag postponed the bridge's construction, the Billings County project is historically important as the first known instance of a county request for state-prepared bridge plans. This procedure became nearly ubiquitous in the years that followed.

In 1913, the first State Highway Commission was authorized by the legislature, with the governor as chairman, the State Engineer as secretary, and a third member appointed by the governor. Continuing his previous responsibilities, the State Engineer was directed to prepare plans and specifications for roads and bridges. He was also, with the aid of the counties, to complete county road maps showing all roads, bridges, and culverts. Despite the law's noble intent to upgrade the state's highway system, the commission's program was hindered in two important respects. First, the legislature did not appropriate funds for the agency's work, even though a constitutional amendment, enacted in 1914, allowed that "the State may appropriate money in the treasury or to be thereafter raised by taxation for the construction or improvement of public highways." Second, the commission had little control over actual road and bridge construction. Most highway projects were handled by the counties, which were under no compulsion to use the commission's services. Apparently some private citizens were highly frustrated by the slow pace of both state bureaucracy and highway reform. Chapter 181 of the 1913 Session Laws is "An Act Authorizing Private Associations or Organizations to Work Upon and Improve the Public Roads at Their Own Expense," with the approval of the appropriate county commissioners.

The 1913 Act sanctioned the efforts of the first organized supporters of good roads in the state, the various Trail Associations and Automobile Clubs which were popular in the first quarter of the twentieth century.[35] By the early 1920s, these organizations and the North Dakota State Good Roads Association (and its successors) boasted memberships in the thousands--members who were inconvenienced and who suffered financial losses because of the state's poor vehicular transportation system. These movements were national ones, with broad and diverse constituencies. They included groups of automobile owners such as the American Automobile Association (1903), organizations intended to promote travel and tourism (such as the various named road associations), and Good Roads associations, supported by landowners, businessmen, and civic boosters. All of these movements were particularly active in North Dakota, however--perhaps due to greater need in the lightly-inhabited, newly-settled state.[36]

By the height of the "goods roads" movement in North Dakota--the 1920s, it was the roadways themselves and not the bridges that were the weak links in the transportation network. In the late nineteenth and early twentieth centuries, counties and townships had focused on "permanent" bridge construction almost to the exclusion of "permanent" road construction.[37] Consequently, the "good roads" movement focused on the need to establish a trunk system of roads across North Dakota. Such a network was finally established by the State Highway Commission by the early 1920s, although in its first years it was only a patched-together collection of former county routes.[38]

The North Dakota State Good Roads Association's vehicle for promotion of their "trunk system" agenda was the North Dakota's Good Roads Magazine which was published in 1921 and 1922.[39] Most articles lamented the high (hidden) costs of inferior roadways, appealing to the rural population for grass-roots support. The magazine rarely mentioned bridges specifically, although the August 1922 issue devoted several articles to showcasing recently completed bridges across the state.[40]

In the State Engineer's 1914 biennial report, a bridge was pictured for the first time: a riveted Warren pony truss, which, despite its modest design and short span, rated placement on the report's frontispiece. The caption read, in part: "Steel highway bridge across Beaver Creek. Billings County. Designed by the State Engineer's Office: Built by Great Northern Bridge Company of Minneapolis." This report detailed bridge and culvert design work done by the State Engineer in twelve counties. In the case of Pierce County, the Engineer received a request "for plans and specifications for wooden, reinforced concrete and steel truss bridges," which "were prepared and furnished in July, 1913." For the study of the state's historic bridges, it is useful to know that standard plans and specifications were being furnished by the state at this date. Apparently, though, the set of plans was incomplete, or not completely satisfactory in some other way. In the same report Jay Bliss, who had become State Engineer in 1913, requested extra funds from the legislature because the state "should be in the possession of standard plans and specifications and should have at all times available the services of a competent [professional] bridge engineer." The report lists three bridge engineers who served during the previous two years, none serving for longer than four months, plus another person described as "Consulting Bridge Engineer."[41] The lack of professional staff apparently prompted the State Engineer to seek the assistance of his counterparts in other states. In his 1916 biennial report, for example, Bliss expressed "the appreciation of the department to the officers of the state highway commission of Minnesota for plans furnished, aid in road and bridge work, and information given to a representative of this office who spent several days in their office."[42]

Given existing legislative authority and minimal funding, the State Engineer could do piecemeal work at best, and more was clearly needed. An early resident reminisced that outside of the Red River Valley "in a Model T Ford you could sit in the car and it would steer itself because the trails were cut in." Leaving responsibility for roads and bridges in the hands of counties and townships created a hodge-podge of quality and design. A primary road in one county might turn into a muddy morass in the next if neighboring counties couldn't agree on route priorities.[43]

<u>b. The Age of Federal Funding (1916-1946)</u>: Clearly it was time for change, and North Dakota was not alone in its faltering steps to develop its road system. The need for increased highway planning and improvement programs had been recognized at the federal level as early as 1893, when the Office of Road Inquiry was created in the Department of Agriculture. (The Office went through several name changes in its early years, before emerging as the Bureau of Public Roads in 1918.) Beginning in 1913 the Office began serving as a conduit for federal monies intended for the improvement of public roads.[44]

Federal support of highway projects took a more dramatic step forward, however, with the passage of the Federal Aid Road Act of 1916. The Act authorized the Department of Agriculture to provide federal aid to the states of up to fifty percent of the cost of approved road construction projects. It also stipulated that applications for proposed projects had to be submitted through state highway departments. This latter provision was purposefully directed to establish centralized authority for road construction in the states and remove control from the counties. This served as an important first step in the effort to bring professionalism and organization to state highway planning across the nation.[45]

The federal government allocated $75 million over 5 years to the states, which was appropriated by a formula weighing population, area, and rural postal-route miles. To qualify, states had to establish a state highway commission, have plans and specifications for roads and bridges approved by the U.S. Bureau of Public Roads (a division of the Department of Agriculture), and match federal funds on a dollar-for-dollar basis.

North Dakota's share of the federal appropriation was 1.53%, or $1,242,000.[46]

Since the Act required the states to establish agencies capable of administering the new federal road funds, the 1917 North Dakota Legislature replaced the state's previous three-member State Highway Commission, which had only advisory powers, with a new and stronger five-member Commission. The commissioners were the Governor, the State Engineer, the Commissioner of Labor and Agriculture, and two appointed individuals. The legislature also created the State Highway Fund, but its appropriations did not come near to matching available federal aid. In fact, the law increasing the motor vehicle tax included a provision returning 90 percent of the taxes raised to the counties in the ratio in which the funds were raised in each county. North Dakota's legislative efforts were the minimum required by the act, and was of limited use compared to the more substantive efforts of other states.[47]

As a result of the North Dakota Legislature's failure to provide adequate funding to match the federal dollars, federal aid projects had to be matched by county funds. The State Highway Commission, rather than becoming the strong central coordinating agency for highway construction in the state as envisioned by the federal law, served the counties and federal government only as an intermediary. The result was a cumbersome process under which each county let its own bids for road and bridge construction with a representative of the State Highway Commission present during bid openings. The poorer and more sparsely settled counties which could not come up with their share of the match became ineligible for federal aid, even though they often needed the subsidy the most. Other counties refused the federal aid feeling they could build roads less expensively even without the match. Road and bridge construction in North Dakota continued to be a piecemeal affair as each county continued to set its own priorities.[48]

An important piece of legislation affecting bridges, however, was passed by the 1919 Legislature when it created the State Bridge Fund. The law permitted the state to pay one-third of the cost of interstate bridges and bridges over navigable waters on the state highway system. The act recognized the fact that the counties could not afford to match federal funds for construction of larger bridges, such as those needed over the Missouri River. Appropriations to the Bridge Fund were on an ad hoc basis until 1925. Thereafter an annual sum of $130,000 was dedicated to the Bridge Fund until the Fund's recision in 1933.[49]

Frustrated with the lack of commitment on the part of some states to meet the intent of the Federal Aid Act, the federal government finally mandated in 1921, that by 1924, the states provide matching funds for road and bridge construction "under the direct control of the state highway department."[50]

Again, the North Dakota Legislature responded minimally. It appropriated all but $200,000 annually of the one cent gas tax to the State Highway Fund. In doing so, the Legislature also removed the responsibility for maintenance of roads from the counties and imposed it on the State Highway Commission. As a result, the Commission continued to find itself unable to provide adequate matching funds for the federal aid. It took an initiative by the voters in 1926 to raise the gasoline tax to two cents per gallon and give all revenues to the State Highway Fund.[51]

The influx of federal dollars for road improvements was not always welcomed by residents of the state. A referendum to match funding for the 1922 federal aid appropriation met with heated resistance, with the commissioners of Cavalier, Grand Forks, Pembina, and Walsh counties passing resolutions against accepting federal aid and with debates being held in other counties. Opponents of federal aid claimed that counties could save money by paying one hundred percent of the cost of roads which did not meet the federal specifications. These people believed that the federal specifications were excessive, while proponents of the referred measure argued that the higher standards would save money in the long term when considering future maintenance costs. Opponents to the referendum voiced tax-saving arguments which had been heard in North Dakota earlier in the local politics of selecting bridge designs.[52]

Although a great many farmers in North Dakota did own automobiles, rural voters feared that accepting federal funding and the move to State control of road and bridge construction would end local control of such matters. Additionally, farmers were not necessarily willing to spend much money to improve the quality of roads and bridges in the state. As late as the 1920s, a farmer from the northern part of the state complained that: "In my opinion, the automobile, poor management, and too much credit have ruined many farmers in this state." Another from central North Dakota complained: "They never have enough money to pay their store bills with, but always seem to have plenty of money for gasoline."[53] Hostile feelings continued in North Dakota for at least another decade: in 1931, the legislature raised the gas tax to four cents, but voters rejected the increase in a referendum.

Such hostility, however, was only a minor facet of the rather overwhelming problem confronted by the State Highway Commission at its inception. J.E. Kaulfuss, Assistant State Chief Engineer, assessed the situation in 1920: "There are in North Dakota approximately 70,000 miles of public highway -- all in more or less improved condition -- generally less." Those 70,000 miles represented one-thirtieth of the entire road mileage in the United States, but the state's annual expenditures, at about $43 per mile, were only one one-hundredth of the total spent on roads and bridges in the country. With a population of 750,000, the state averaged ten people per square mile, as well as ten people per mile of road.[54]

c. New Deal Programs: On the eve of the Great Depression, the State was spending about $800,000 a year on "structures", about one quarter of the entire highway budget. Of this, the State spent approximately $400,000 annually on standard bridges and culverts, with bridges claiming about two thirds of that sum. With this amount, about fifty standard bridges were built each year. The other $400,000 was directed towards special bridge construction. Because some large projects required an accumulation of funds over several years to make construction feasible, actual expenditures for special bridges ranged from $100,000 to $1 million annually.[55]

On December 28, 1930, a fire gutted the North Dakota State Capitol. The highway department lost a large portion of its office equipment and files, including virtually all inspection reports and all standardized plans. Although this loss would be of considerable concern to future historians attempting to chronicle the state's bridge building practices, the agency itself most immediately regretted the loss of plans for projects in progress, such as bridges at Jamestown, Cavalier, and Forest River, which required new surveys and designs. Despite the damage, concern was so intense about meeting deadlines to retain all federal aid that the department was back on duty in makeshift quarters the following day.[56]

By the 1930s, some turn-of-the-century bridges were starting to show their age. Of special concern were those on roads that had been adopted for the state highway system. A.D. McKinnon, head of the Highway Commission, announced in January 1932: "During the past year a somewhat definite program was started for the replacement of the old County and Township bridges on the improved part of the State Highway System." He continued: "Contracts were awarded for the replacement of thirteen and the widening of three bridges."[57]

The coming of the Depression turned out to be good news for road and bridge construction. The 1932-33 Federal Emergency Fund removed previous restrictions, for the first time allowing the use of federal funds for bridges within municipalities. In 1932-33, the federal government made $120 million available to states for road improvements, plus $16 million for roads in national forests and parks and on Indian Reservations.[58] The 1933 National Industrial Recovery Act gave North Dakota almost $6 million and waived the aid-matching provision, providing 100% of the cost of construction. In addition, the federal government provided over $2 million of Federal Emergency Relief Administration labor to the state as well as $900,000 in cash from the Public Works Administration for materials.

The Hayden-Cartwright Act of 1934 allocated almost $3 million to be divided among North Dakota counties and used "not more than 50% on Federal highways, not less than 25% each on feeders and municipals, 1% on landscaping projects, and a substantial amount on railroad grade separations." The act also gave the state two additional appropriations of $1.9 million each, spread out over the years 1935 to 1938. The availability of federal funds apparently allowed North Dakota to rationalize the diversion of over $3,140,000 of state highway funds from 1933 to 1935 to pay state bond interest, apparently a more pressing cause.[59]

With the Hayden-Cartwright Act, Congress initiated a program for immediate highway construction projects. "The elimination of traffic hazards, particularly those caused by railroad grade crossings" received second priority in the list of eligible projects. Deaths at railroad crossings were a serious problem that had been publicly debated since the beginning of the 1900s. Nationally, nearly 4000 deaths at railroad crossings were recorded in 1902; that figure increased to nearly 14,000 in 1921. Railroad companies tried a wide assortment of mechanical and electrical safety devices at the crossings without successfully reducing accidents. In trying to gain an understanding of the psychology of motorists who ignored crossing signals, studies showed that fewer than ten percent of motorists stopped, looked, and listened when they encountered crossing signals. This led planners to recognize the need for a more costly solution: grade separations.[60]

In North Dakota, with its wide treeless prairies and straight, fairly level roads, the frequency of crossing fatalities would not have reached those levels found in more hilly, vegetated rural areas or urban centers. Still, grade-crossing-elimination projects were undertaken under the federal program. Most were in urban areas, and were built with the highway passing below the railroad grade. Because of their location and design, these urban underpasses were often among the minority of North Dakota bridges provided with electric lighting; they were also often outfitted with another rarity among the state's bridges: applied ornamental detail.

Other New Deal-era work programs may have also played a role in road and bridge improvement in North Dakota during the 1930s. The two most prominent such efforts were the Works Progress Administration (WPA) and the Civilian Conservation Corps (CCC), both of which emphasized labor-intensive projects as a means of reducing unemployment. While the WPA is known to have sponsored scattered bridge projects in North Dakota, the number of such structures is probably not extensive; local governments typically used WPA assistance for larger projects such as public buildings and airfields. Some WPA funding was apparently funneled directly to the counties with minimal restrictions on use, and some of these monies found its way to local bridge projects in scattered counties throughout the state. For example, Stark County used WPA laborers to construct steel stringer bridges with stone abutments. In contrast to the WPA program, workers at CCC camps often participated in a wider variety of smaller-scale projects. Road and bridge improvement jobs were occasionally undertaken by the CCC, but few North Dakota bridges are documented products of the CCC program. Among the known CCC bridges in the state are stone structures at Turtle River State Park in Grand Forks County. Stonework was often promoted for relief projects as it was found to be particularly rewarding and less tedious than conventional bridge building; it was also labor-intensive and well-suited to workers with a variety of skills.[61]

<u>d. Epilogue: World War II and Beyond</u>: Federal support of road and bridge work during the 1930s helped the nation's economy by providing jobs and improving the infrastructure. A bigger overall economic boost, however, came with the onset of World War II. Bridge construction in North Dakota virtually ceased during the war years, but the period proved to be a watershed between two phases of bridge construction. The first, which witnessed the evolution of theory and techniques spanned the transition from horse-and-buggy days to the age of the automobile. The post-war period, in turn, brought dramatic innovations in response to the country's growing reliance on cars and trucks for commercial and recreational use.

The decades following the end of World War II saw an intense effort to improve America's road system. This was prompted by Cold War defense concerns, by the demands of increased traffic and loads, and by burgeoning suburban development. On the national level, these concerns culminated in 1956 in the creation of the U.S. Interstate Highway System. Such a massive program required standardization in construction, and this is evident in the utilitarian steel- and concrete-girder bridges that were produced. State and local bridge designs followed suit.

The war stimulated experimentation with new technologies, and this directly and indirectly influenced bridge design after 1945. Surplus military bridges, such as Bailey trusses, were sold for civilian use and gave decades of service. Wartime shortages, particularly of metal, led to advances in welding, which conserved material by eliminating rivets. Welding was accepted slowly in bridge design, but eventually proved a reliable alternative. Metal shortages also spurred improvements in concrete construction. The first prestressed concrete bridge in the United States was erected in Philadelphia in 1948. Prestressed and post-stressed concrete bridges subsequently became commonplace. (These terms refer to concrete girders, which are cast with an internal tension intended to the pressures of a bridge load.) For shorter spans, cast-in-place and precast concrete culverts were often substituted for ageing truss and beam spans.

By virtue of their standard designs, modern concrete and steel structures usually lack aesthetic or technological distinction. The older structures that they replace have often served as local landmarks. While replacement of many older bridges is unavoidable, their loss greatly alters the built environment--just as their construction once had. Without them, the landscape becomes more homogeneous. This condition is a significant mark of the era between World War II and today.

D. Context 2: Evolution of North Dakota Bridge Design and Engineering, 1885-1946

1. *Introduction: The Technology of Bridges*

Simply put, a bridge is a human-made structure designed to span an obstacle to travel. Often, this obstacle is a river or other watercourse, but it might also be a ravine or gorge, or even another man-made feature, such as a railroad or canal. The basic concept of a bridge and recognition of its value have existed for millennia; during that time, humans have continually applied their evolving technological knowledge to the concept to produce an amazing variety of bridge forms, configurations, and styles. The array includes arch, truss, suspension, slab and other forms of bridge design built of wood, stone, concrete, metal, and other materials. Dozens of smaller variations exist within these broad categories.[62]

The earliest bridges were constructed of wood, perhaps consisting only of a log thrown across a stream. Timber has remained a common bridge-building material, and in the United States has found extensive use in a variety of forms. By far the most common form of wood bridge consists of a number of parallel logs or timbers (called "stringers") placed across a stream or obstruction and then covered with wood decking. This extremely simple bridge design was widely used in America's earliest bridges, and remains useful today for small, lightly traveled spans. Such a design, however, was inadequate for bridges of more than a few feet in length, and more complex wooden bridges were consequently developed. The addition of abutments constructed of timber piles driven into the ground was an early enhancement to increase bridge stability and longevity. Similarly, additional timber piles could be driven at a proposed span's intermediate points (called "piers") to increase the bridge's allowable length. This resulted in the first multiple-span bridges, a timber bridge form that was often used in frontier areas to produce bridges of considerable length. In more sophisticated examples of this bridge type, additional longitudinal timber bracing was added between the intermediate piers; this resulted in the "trestle" bridge form used in some early roadways and commonly seen in railroad construction. Major wooden railway trestles could be constructed to bridge barriers which were hundreds of feet long and hundreds of feet deep.

Despite their increasingly sophisticated design, however, bridges comprised of timber piles and stringers were hampered by the relatively short span allowed between the piers. This restriction, largely a product of the limited tensile strength of the wood itself, led to the development of designs which utilized a rigid assemblage of built-up shorter members to span a relatively long distance. These designs, collectively known as "trusses," were pioneered in timber bridge construction but are more commonly associated with metal bridge design. Both timber and metal truss bridges consist of two truss assemblages, placed vertically and parallel to one another across the span. The deck utilized for travel is laid between the two truss assemblages, usually at the bottom of the trusses, but occasionally at the top or at a midpoint. Timber truss bridges were appearing in both Europe and America by the middle of the eighteenth century, in a variety of configurations.

Timber trusses were often utilized in nineteenth- and early twentieth-century American bridges. The most common truss configuration was the Howe (patented 1840), named after William Howe, its designer. The Howe truss featured heavy timbers placed diagonally across the truss to carry compressive loads; lighter, vertical members (usually of iron) were placed between the diagonals to handle tensile loads. Although the greater stability and longevity of metal truss designs eventually doomed the Howe to extinction, it was an important pioneer in truss bridge design. Today, large highway bridges constructed of timber have disappeared, replaced with bridges constructed of other materials. Use of the timber bridge today is largely restricted to small, single-span, stringer configurations, where economy and simplicity of construction is deemed more important than strength or longevity.

Stone is a second bridge material with ancient origins. Long before the introduction of the timber truss, bridge designers were experimenting with other methods for lengthening the allowable span of a bridge. The earliest of these efforts involved the construction of arch bridges of either stone or masonry. The arch itself is an ancient architectural form used in door and window framing; the Babylonians began using the form for bridge construction as early as 4000 B.C. Other impressive multiple-arch bridges followed during Greek and Roman times. Stone and masonry arch bridges were massive, solid, and heavy, and relatively time-consuming to construct. Relatively few were constructed in the United States, but they are significant in American bridge history as the precursor of the concrete-arch bridge, which appeared in large numbers during the early twentieth century.[63]

Wood and stone remained the dominant bridge-building materials until well into the nineteenth century. As the 1800s progressed, however, builders began utilizing cast iron (and later wrought iron) in their bridge designs. The amount of this use increased during the period as iron structural members gradually became less expensive and more structurally sound. Although a few arch bridges were constructed of iron, the material proved far more suited to the truss bridge form, and by the late nineteenth century the iron truss was the preferred method of bridging a large channel. The rapid popularity of the iron truss resulted in tremendous experimentation with the form, and a variety of new truss configurations appeared in America during the mid-nineteenth century. Of the many designs attempted, two achieved a significant level of permanence and popularity: the Pratt and the Warren. The Pratt design was patented by Thomas and Caleb Pratt in 1844; it featured relatively short, vertical members acting in compression and longer diagonal members acting in tension. By the late nineteenth century, the Pratt design was by far the most common form for metal truss bridges. The Warren truss followed the Pratt and gradually succeeded it in popularity; it consisted of sequential diagonal members (in the shape of a "W") acting in both tension and compression.[64]

A number of design advances took place as the era of truss bridges continued. Easily the most significant of these was the transition from iron to steel as the primary structural material. The use of steel provided both increased strength and durability, allowing for even longer spans. The methods of assembling bridge trusses also evolved, as individual truss members (or "chords") could be built-up from varying combinations of different structural sections. The methods of connecting truss members to one another also changed. By the late 1800s, metal trusses were typically "pin-connected;" that is, held together by large metal pins at the points where truss members met. Such structures were easily assembled in the field with only minimal on-site equipment. By 1900, though, the technology of riveting structural steel in the field had advanced to the point where pinned connections could be replaced with riveted, or "rigid," connections. By the mid-1910s, most bridge trusses utilized rigid connections. Although most rigid connections were riveted, bolts were occasionally substituted when it was impractical to perform field riveting during final truss assembly. These rigid-connected bridges resulted in a more stable structure under heavy load.[65]

Fabricators of bridges purchased standard lengths and shapes of metal products from foundries and rolling mills. Their plans were large industrial complexes which housed several distinct functions. After receiving an order for a bridge, clerical staff arranged contractural and shipping details while the engineering department prepared detailed plans, lists, and instructions for fabrication and erection. The template shop made or used already existing wood patterns to guide workers in the riveting shop, who cut, punched, and bored the metal. Fabricators also did as much assembly as was possible, riveting together chord members, struts, and other built-up sections before transporting them to the bridge site for assembly. For pin-connected bridges, two other departments were also important. The machine shop turned the pins, and plaining and finishing. The forge shop produced eye-bars and other items requiring foundry and blacksmith work.[66]

Although most nineteenth- and early twentieth-century metal bridges were trusses, metal also began to be used for a variety of other bridge forms, some utilitarian and some spectacular. By the early 1900s, small stringer bridges often utilized steel rather than timber in their construction; this allowed for the construction of stringer bridges that were longer, more durable, and able to withstand heavier loads. As the twentieth century progressed, steel stringer bridges became more and more common. Improved steel technology allowed for the construction of longer and longer steel stringer bridges, so that by the mid-1900s stringer bridges were able to fill nearly all the applications which had called for a truss a generation before. The very longest spans, though, remained the realm of the truss and of a handful of more exotic forms, including steel arch bridges and large suspension bridges. Often, larger twentieth-century trusses were cantilevered from their piers, which increased the span length still further.

Concrete is the most recent material to see wide use in bridge construction. Like masonry, concrete functions well under compressive loads, but not under tensile loads; this meant that nearly all pre-twentieth century concrete bridges were arches. Concrete arch highway bridges, in a variety of forms, enjoyed moderate popularity throughout the first half of the 1900s, although the relative economy of steel generally made it a more attractive choice. Other forms of concrete bridges evolved during this period, as well, eventually supplanting the concrete arch and making inroads into the steel and timber bridge markets. It was found that small bridges could be constructed of simple concrete slabs. Later, methods of forming concrete beams and girders were developed which allowed them to serve as stringers in relatively long bridge spans. The concrete "T-beam" bridge was often used for relatively short spans by the 1920s; this form strengthened the concrete slab by adding a series of concrete beams to the superstructure, acting as stringers. Later, even longer concrete "girder" bridges were developed, characterized by heavy concrete beams running beneath the outer edges of the bridge deck. Concrete girders remain a prevalent bridge form today.[67]

2. Designs for County-sponsored bridges

<u>a. Predominant Bridge Types</u>: Nationally, local governments were making wide use of iron and steel for through trusses in the 1890s, and in some cases, they began building metal pony trusses where shorter spans were needed. During the first two decades of the twentieth century, the use of timber truss bridges all but disappeared as steel trusses, especially pony trusses, and steel stringers were adopted for "permanent" construction. By 1912, Milo Ketchum, one of the leading bridge engineers in the United States stated:

> Timber was formerly quite generally used in construction of highway bridges, and is still used for temporary structures in locations where timber is cheap and iron and steel are relatively expensive.[68]

North Dakota, however, presents an anomaly to the national trend. Although some North Dakota counties began to build iron bridges by the mid-1880s, combination wood-and-iron trusses apparently remained the most widely used structural type for longer bridges through the end of the century. More unusual, however, is the fact that some North Dakota counties continued to build large numbers of timber stringer and combination bridges into the first two decades of the twentieth century. For example, McHenry County built combination bridges at least through 1905, when it awarded a contract for ten combination bridges.[69] Similarly, Richland County built combination bridges until at least 1907, when the county board consulted with the faculty of the State Science School at Wahpeton about the possible benefits of switching to steel bridges.[70] H.C. Frahm, Ward County Surveyor, reported "nine bridges were built [in Ward County] in 1914, eleven in 1915 and 20 in 1916. Most of these bridges are heavy pile, timber and combination construction." As late as 1917, the Mountrail County Commissioners accepted a bid for eight wood bridges -- two of them trusses.[71] No wood-and-iron truss bridges survive in the state today.

Notwithstanding the prolonged popularity of timber bridges, metal truss bridge construction in North Dakota otherwise followed the national trends. Most of North Dakota's nineteenth century metal truss bridges were pin-connected Pratt through trusses. The counties constructed these bridges over larger rivers in attempts to open new markets and to connect otherwise detached county regions. Their importance is evidenced in their cost which was often the second largest single expenditure of county funds, following only the cost of the county courthouse building itself.

A few pin-connected metal pony trusses were built in the nineteenth century, but the more economical timber bridge continued to dominate for shorter spans. As the public's demand for more and better bridges persisted, the counties found their budgets increasingly being eaten away by maintenance and replacement costs. As a result, they turned to "permanent" steel bridges even for the shorter spans. During the first decade of the twentieth century, the pin-connected Pratt pony truss came into general use for spans between 40 and 80 feet. A relatively large number of these pony truss bridges survive in North Dakota in 1996, including the West Antelope Bridge (32BE41) in Benson County, and the Sheyenne River Bridge (32NE49) in Nelson County.

Around 1910, as field riveting techniques were perfected, some North Dakota counties experimented with riveted Pratt pony trusses. In spite of the Pratt's past popularity, it was quickly supplanted in popularity by the riveted Warren pony truss. In North Dakota, pin-connected Pratt through trusses remained the choice for longer spans through the 1910s with a few examples being built into the 1920s. A few Warren through and riveted Pratt through trusses were built during this period, presaging the development of the riveted Parker through truss. A good example of a riveted through truss structure is the Porter Elliott Bridge (32TR690) in Traill County.

At about the same time North Dakota counties were shifting to riveted bridges, concrete bridge construction was also making its debut. The earliest documentation in North Dakota county records of a concrete bridge was found in Ramsey County. In May of 1907, the commissioners advertised for eight bridges: "bids to specify price for steel bridges and also of concrete and steel the same as the bridge built ... last year." The commissioners accepted the bid for concrete bridges even though it was $1000 more than the bid for steel bridges. They stipulated that the company furnish plans and specifications acceptable to the board. The commissioners were evidently pleased with the bridges and continued to build almost exclusively in concrete from that date forward.[72] Several other counties in North Dakota began building concrete bridges during the early 1910s, mostly in the relatively settled and prosperous eastern third of the state.[73] A good surviving example is the Crystal Bridge (32PB78) in Pembina County.

<u>b. Sources of Early Bridge Designs</u>: While a few North Dakota bridge projects utilized the services of professional engineers for bridge design, most did not. Those projects which were designed by professional engineers were generally either large crossings of the Missouri or Red Rivers, or were among the state's earliest attempts at building long-span bridges. Occasionally, nineteenth-century county commissioners' records list payment to an unidentified individual for preparing bridge plans. In 1884, for example, the Traill County Commissioners retained a civil engineer to prepare plans and specifications for bridges in the county.[74] Such indications of the use of outside consultants were uncommon, however, and grew more infrequent as highway bridge construction in the state became more commonplace.

In most instances, the alternative to employing a costly professional bridge engineer was to rely on the bridge companies themselves for plans and specifications. Most counties routinely did just that, until the private bridge designs were replaced with standard State Highway Commission plans. In counties which had strongly competitive bridge bidding, agents representing the competing bridge companies would occasionally argue the merits of their particular designs before the commissioners as part of the selection process. In other counties, where a single bridge company dominated the bidding process from year to year, that company would usually supply bridge plans and specifications to the county in advance, thus forcing other bidders to prepare cost estimates based on their competitor's blueprints.[75]

Few county commissioners had the expertise needed to adequately evaluate a bridge design or proposal; indeed, most counties had no employees with such qualifications. This implies that the selection of a successful bidder was not necessarily an informed decision. Instead, proposals were presumably judged largely on price, or on the perceived reputation of a bridge company or of its local agent. The liabilities of this arbitrary method were obvious to professional observers. As early as 1905, the president of the American Society of Civil Engineers recommended that the "only fair and business-like method" for purchasing bridges was "to let contracts for structural steel work on a pound-price basis, on designs and specifications furnished by an experienced engineer employed by the purchaser."[76] He went on to explain:

> Bridges are frequently designed by incompetent or unscrupulous men, and the contracts are awarded by ignorant county officials, without the advice of a competent engineer. The merit of the design receives generally no consideration, and the contract is awarded in many cases to the one offering the poorest design and making a bid which is satisfactory to the officials, if not the taxpayers.[77]

Despite the inadequacies of the period's bridge contracting procedures, however, most of the bridges constructed during the period were apparently well-suited for their early twentieth-century roles. The survival of many of these bridges at the end of the twentieth century is a testimony to the caliber of their structural design and materials.

3. *State-sponsored bridge designs*

The first known mention of a state-sponsored bridge design came in the 1912 State Engineer's report, which indicated that the office had prepared two sets of plans and specifications for a bridge over the Little Missouri River at Marmarth, one for a steel bridge and the other concrete. Since Billings County Commissioners had only requested plans for a steel bridge, the State Engineer's office, in providing both plans, was obviously promoting concrete as an alternative.

By 1916, the State Engineer's preference for concrete became more overt. The biennial report published in that year declared that "the high price of steel favors the construction of reinforced concrete bridges. There is no better material for the construction of bridges than reinforced concrete, and it is urged that it be used in the construction of bridges whenever possible." The report included standard plans for a 40-foot reinforced concrete girder span and a 3-foot by 3-foot reinforced concrete box culvert. The girder plan featured an 18-foot roadway and a solid concrete rail with recessed panels.[78]

Despite the availability of plans from the State Engineer or the authority to hire a county highway superintendent, many counties chose not to seek professional assistance for their bridge construction. Jay Bliss described the problem in North Dakota in the State Engineer's 1916 report:

> Many counties do not as yet make a practice of employing a competent engineer to assist in road and bridge work ... Many believe that in level or gently rolling country an engineer can be of no service. However, hundreds of instances of roads located from a few feet to a few rods off from section lines, expensive grades built in cornerwise or off the line, and bridges improperly located, in a great many instances with insufficient waterways and on frail foundations, amply prove the contrary.

He cautioned: "Particularly in the building of bridges, the counties should require careful inspection during erection, especially during the time when the foundation work is being done." And he bemoaned the fact that:

> It is the exception rather than the rule to find a county that places this work in the hands of an engineer. The system generally in vogue in the state, of permitting the various bridge companies, many of whom never have the bridge sites examined beforehand, to submit bids on their own plans and to furnish their own inspection, as well as to make out their own bills for extras, is indefensible.

In his reports, Bliss illustrated these problems with photographs of a masonry arch with an opening too small for the stream beneath it, an eighty foot truss over the Knife River where "Superstructure is First Rate" but "Note Poor Foundation," and a collapsed concrete span in Ward County captioned with irony: "A Result of a Saving of Engineering Expense."[79]

Bliss' comments reflect a frustration that was to continue after passage of the Federal Aid Road Act. Since the counties were required to provide match for federal aid until 1926, many of them appear to have rejected the standardized state plans in favor of those of the private bridge building companies. This is indicated by several counties' utilization of bridge types during the early and mid-1920s which were not included in the standard state plans. While the pin-connected Pratt through truss design, for example, had almost universally fallen from use by 1915, such bridges were constructed in 1921 and 1925 in McHenry and Foster Counties, respectively, by the Fargo Bridge & Iron Company. This strongly suggests that such bridges were constructed from plans supplied by the contractor, rather than by the state.

Nonetheless, the State Engineer's office continued to promote the use of standardized plans and by 1920 had developed new designs for reinforced concrete bridges including reinforced concrete box culverts, abutments and piers, slab spans, girder spans, and T-beam girder spans. L.O. Marden, serving as State Bridge Engineer, reported that farmers and truckers appreciated being able to drive with assurance over a standard design bridge "without stopping to examine the old type of bridge (which may be shaky), without a silent prayer, or trust to luck that his outfit may pass over the structure without landing in the bottom of the creek."

The North Dakota State Highway Commission seems not to have promoted concrete-arch bridge construction, which was popular among some Midwestern state highway agencies during this period.[80] This decade saw, however, a few noteworthy false-arch bridge designs, such as the cantilevered T-beam in Minot and two park bridges in Valley City, where the setting called for a more picturesque form.[81]

It was not until 1926 and passage of the 2 cent per gallon gasoline tax that the state was finally able to match the federal aid without county assistance. Although not specifically tied to the passage of the act, the State Highway Commission also announced that "now all plans for all classes of highway work are drafted wholly and solely by the engineers on the Department payroll."[82]

That same year, the Commission completed drafting a new set of bridge plans, having concluded that "a large number of our standard plans for reinforced concrete bridges were becoming obsolete." The biennial report cited two reasons: "first, the regular changes for advancement in general or standard engineering practice; and second, the elimination of a large number of sizes of reinforcing bars as a result of industry standardization."[83]

Besides their popularity with the State Highway Commission, concrete bridges apparently also appealed to the general public. When planning was underway for the Sorlie Memorial Bridge (32GF279) in Grand Forks in the late 1920s, many in the community pressed for a concrete structure. The rigidity of concrete, however, was not compatible with the fluctuating banks of the Red River. Clifford Johnson, the state bridge engineer at the time, explained that:

> local interests and personal tastes and preferences had to be subordinated to engineering judgment. . . . The Engineers did not claim that it was impossible to build an all concrete bridge at this location. The Engineering Profession, in general, does not admit that anything is impossible but it does recognize the fact that what is possible is not always practical.[84]

Along with the standardized plans for concrete bridges, the Commission produced plans for steel truss and steel stringer bridges. These were evidently meant mainly for use by the counties: the 1926 Biennial Report listed no steel stringer bridges and only three steel truss bridges constructed on federal aid projects.[85]

The late 1920s saw a resurgence of wood bridge building in North Dakota. Clifford Johnson, North Dakota Bridge Engineer, explained "that the so-called permanent bridges are not always permanent, and that timber bridges are not always short lived or temporary." The prototype for the state-designed timber bridge was erected in McHenry County in 1928 on State Highway No. 9 (now No. 52) over the Wintering River west of Drake. The eight span trestle was 137'-6" long with a roadway 22 feet wide. Economics drove the decision; the bridge cost about 50 percent less than alternate bids for a concrete structure. In a 1931 speech, A.D. McKinnon, Chief Commissioner of the Highway Commission, asserted: "It will be the policy of this Department in the future to use more of these timber treated bridges, especially on our secondary highways and thus reduce our construction costs." That year contracts were let for 17 timber bridges at an average cost of $45 to $48 per linear foot versus $91 to $108 per foot for concrete or steel.[86]

State Highway Department designs for wood bridges were limited to timber stringers; by the 1920s, timber trusses were not competitive with steel trusses. Given load limits during that period, the maximum span for a timber stringer bridge was about 40 feet. In addition to initial materials cost, timber bridges offered several other advantages. They could be constructed quickly under any weather conditions. They could be moved, expanded, and repaired rather easily. If demolition was later necessary, salvage value for the timbers was relatively high. Fire was the major hazard, but according to Clifford Johnson, "the number of bridges destroyed by fire seems to be extremely small."[87]

Besides the smaller bridges, the Bridge Department engineers designed several important larger bridges including the Four Bears (Elbowoods), Verendrye (Sanish), and Lewis and Clark (Williston) bridges over the Missouri River; the Roosevelt (McKenzie County) and Killdeer (Dunn County) bridges over the Little Missouri; the Wahpeton-Breckenridge, Front Street and Northern Pacific Avenue-Center Avenue (both Fargo-Moorhead), Traill County-Halstad, Sorlie Memorial (Grand Forks), and Pembina bridges over the Red River.

While all of these bridges were typical designs and not unusual for their time, the Sorlie Memorial Bridge received national attention for its substructure. Clifford Johnson, bridge engineer for the North Dakota Highway Department, praised the design by his department as "the boldest attempt yet made at resisting or absorbing the bank movement of the Red River with a permanent structure." The unusual feature of the bridge was the end bearing. Four 38-inch wheels resting on a track 7½ feet long under the end of each truss allowed for movement of the banks and expansion and contraction of the superstructure of up to two feet. With each movement of two feet, the bridge was designed to be "raised slightly" while the tracks under the wheels were moved back.[88]

The one State Bridge Fund bridge designed outside the North Dakota Bridge Department was the first highway crossing of the Missouri River in the state, the Bismarck-Mandan Bridge, also known as the Liberty Memorial Bridge (32BL114). This impressive triple truss structure opened in July 1922. The bridge was designed by world-famous engineer C.A.P. Turner of Minneapolis. Turner's design provided three main spans, which he called a "novel type" and "decidedly interesting." The trusses are 476-foot modified (sub-divided) Warren trusses, also called "Warren-Turner" trusses, and were used for the first time on this bridge. According to Turner, "the economy of this type of truss lies in the small number of main joints, the reduction of the number of nominal members ... to a minimum and the utilization of rolled shapes in the longest mill lengths so that the amount of effective material lost by punching rivets is more than gained in the reduction of detail weight as compared with pin-connected spans. This type of riveted span thus has the advantage of economy of weight with the added stiffness and opportunity to make lateral connections of the best type without complicated details."[89]

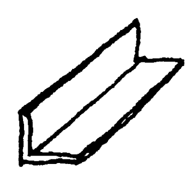
Following his election in 1924, however, Governor Sorlie encouraged the design of all bridges in-house. He referred to the Bismarck-Mandan bridge when he observed: "The fact that the Williston and Sanish bridge engineering costs are nearly two-thirds lower than that for the other big bridge across the Missouri river certainly proves the soundness of our present policy of doing all our own engineering work. Besides, it will build up our highway engineering forces and make them more self-reliant to tackle any of the engineering problems presented by our State. We shall be proud of these two new bridges when completed and prouder still that we did it ourselves."

Major bridge design projects kept the Commission's staff so busy that its 1928 report noted, "considerably more than half of the time and energy of the Bridge Department forces has been devoted to the larger or special bridge projects for which the 1925 and 1927 Legislatures made appropriations from the State Bridge Fund." Perhaps for this reason, the Commission occasionally overlooked the governor's counsel and turned to "outside" designs, relying on the patented "Marsh Rainbow Arch" for concrete bridges in Mott and Valley City (32BA42), and on the Minnesota and South Dakota highway agencies for various interstate bridges.[90]

E. Glossary of Bridge Design and Engineering Terms

Abutment Substructure supporting the end of a span and retaining the approach embankment.

Angle Iron A structural member with a cross-sectional shape similar to the capital letter "L".



Angle iron

Approach Span A span between a bridge's primary span and the approach embankment.

Backwall A retaining wall behind a bridge abutment.

Batten Plate A strip or bar used to join structural members.

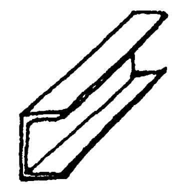
Beam A structural member laid horizontally carrying vertical loads along its length and subject to bending.

Bottom Chord The bottom supporting members of a truss.

Bowstring Arch An early metal truss bridge type in which the upper chord is curved in an arch shape.

Cantilever A structural member which projects beyond the interior pier.

Channel Section A structural member with a cross-sectional shape similar to the capital letter "C".

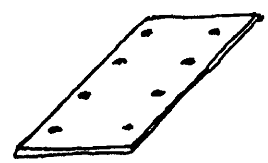


Channel

Compression Type of stress involving pressing together.

Counter A tension-resisting diagonal truss member used at locations where the main diagonals might experience stress reversal (alternate between tension and compression).

Cover Plate A continuous sheet of structural steel used to join two or more parallel structural members.



Cover plate

Cutwater An enlarged area of a pier (usually V-shaped) intended to deflect water, ice, and floating debris from the pier.

Deck The floor of a bridge.

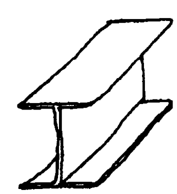
Eyebar A structural member consisting of a long bar or rod body with enlarged forged or punched ends.

Flange The horizontal bars of a rolled I-beam extending transversely across the top and bottom of the web.

Floor Beam A horizontal member usually located transversely to the general bridge alignment.

Gusset Plate A steel plate stiffening an angular meeting of two or more members in a framework.

I-beam A structural member with a cross-sectional shape similar to the capital letter "I". The top and bottom hori-

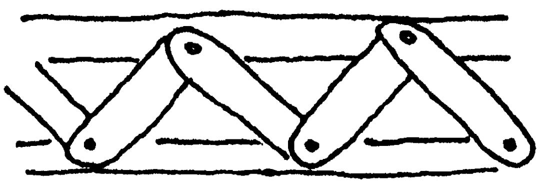


I-beam

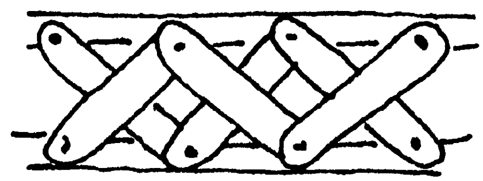
zontal portions are the flanges and the center vertical portion is the web.

Lacing A design where two structural bars, channels, or angles on a truss are joined by a series of bars forming a "V" shape. Also see lattice.

Lattice A design where two structural bars, channels, or angles on a truss are joined by a series of bars forming an "X" shape. Also see lacing.



Lacing



Lattice

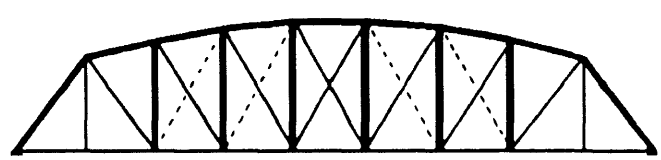
Lateral Bracing The bracing assemblage engaging a truss perpendicular to the plane of the truss intended to resist lateral movement and deformation resulting from wind and lateral vibration.

Lift Bridge A bridge with a movable span, intended to provide temporary clearance for river traffic. The movable span may rise vertically, or may rotate.

Movable End The end of a truss or other bridge member which rests on its pier or abutment in a way to allow for the expansion and contraction of the bridge material.

Outrigger An outward extension of a vertical member in a truss, intended to increase the truss' lateral stability.

Parker a Pratt truss with a polygonal top chord.



Parker truss

Pier Stone, concrete, brick, steel, or wood structure to support the ends of the spans of a multi-span superstructure at an intermediate location between its abutments.

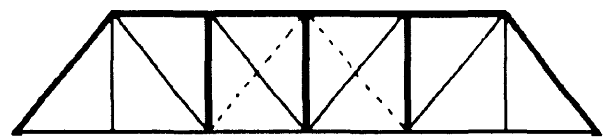
Pile A wood or steel shaft driven into the earth to carry loads through weak soil strata to a depth capable of supporting necessary loads.

Pin A cylindrical bar used to connect the members forming a truss.

Pony Truss A low through truss which has no overhead bracing.

Portal The approach or entrance to a bridge.

Pratt A bridge truss type with diagonals in tension and verticals in compression.



Pratt truss

Rigid-Frame A type of concrete bridge with the deck slab and abutments cast and reinforced together.

Steel Girder A type of bridge using large beams built of steel plates and angle irons to span between the abutments.

Steel Stringer A type of bridge using steel I-beam joists to span between the abutments

Stringer A steel or timber joist supporting the bridge deck and resting on the floor beam.

Strut A structural member designed to resist compressive stresses.

Substructure The abutments, piers, or other constructions built to support the span of a bridge superstructure.

Superstructure The entire portion of a bridge structure which primarily receives and supports traffic loads and in turn transfers the reactions resulting there to the substructure.

T-Beam A type of concrete bridge where the deck slab and beams are cast and reinforced together.

Tension Type of stress involving an action which stretches or pulls apart.

Through Truss A truss where the floor elevation is nearly at the bottom, so that traffic travels between the supporting trusses.

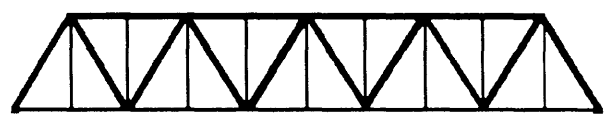
Timber Stringer A type of bridge using wood joists to span between the abutments

Trestle a bridge (usually timber) whose stringers rest on a framework of vertical members joined together with horizonal and diagonal bracing.

Truss A jointed structure made up of individual members arranged and connected, usually in a triangular pattern which acts as a large beam.

Upper Chord The top longitudinal member of a truss.

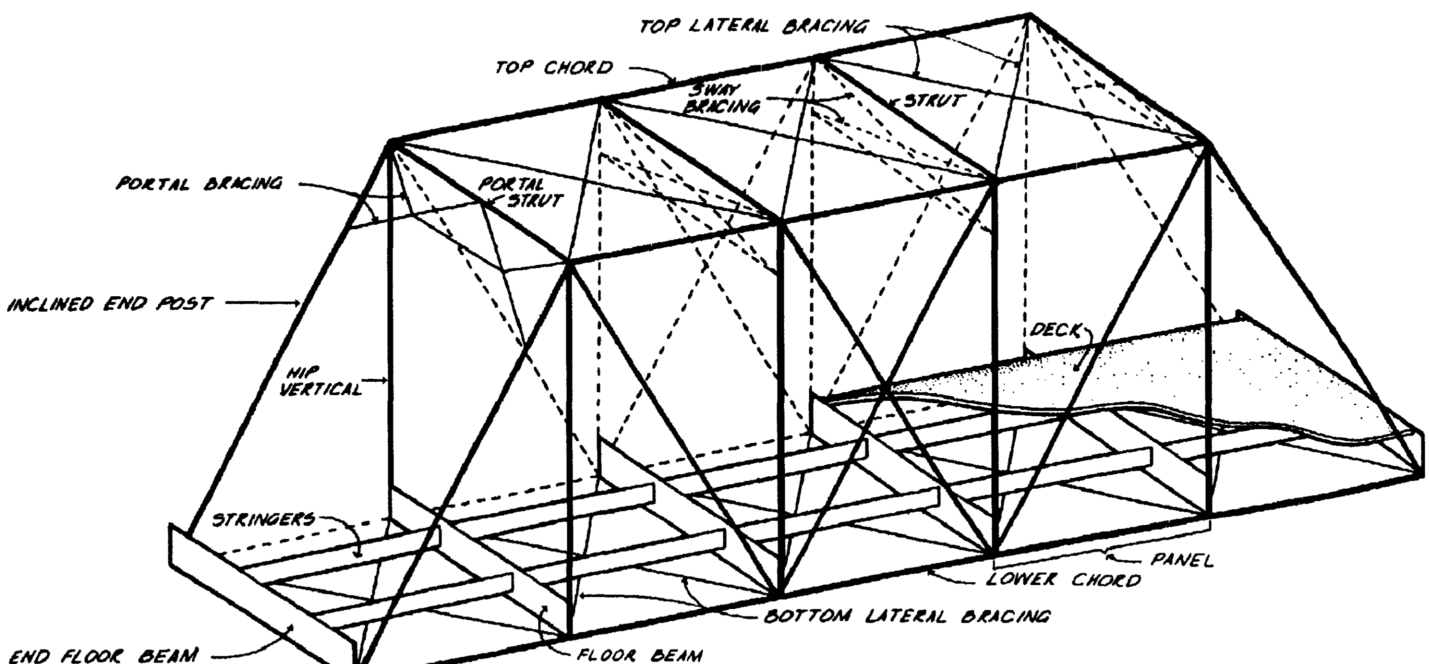
Warren a bridge truss type that has a triangular web system. The diagonals carry both compressive and tensile forces.



Warren truss

Web The vertical center portion of an I-beam.

Wingwalls An angled retaining wall extension of an abutment intended to retain the side slope material of an approach roadway embankment.


TOP LATERAL BRACING
TOP CHORD
SWAY BRACING
STRUT
PORTAL BRACING
PORTAL STRUT
INCLINED END POST
HIP VERTICAL
DECK
STRINGERS
PANEL
LOWER CHORD
BOTTOM LATERAL BRACING
END FLOOR BEAM
FLOOR BEAM

Endnotes for Section "E"

1. For a history of North Dakota prior to statehood, see Elwyn B. Robinson, History of North Dakota, (Lincoln: University of Nebraska Press, 1966), Chapters 6-10. For a discussion of early military roads, see Harold E. Briggs, "Early Freight and Stage Lines in Dakota," North Dakota Historical Quarterly 4 (July 1929): 229-261.

2. Robinson, History of North Dakota, 113-116, 120-122.

3. Harold E. Briggs, "Pioneer River Transportation in Dakota," North Dakota Historical Quarterly 3 (April 1929): 159-181.

4. For a general history of railroads in North Dakota, see Robinson, History of North Dakota, 122-132, 140-143.

5. Ibid. For a more detailed discussion of the NP's early years, see Louis Tuck Renz, A History of the Northern Pacific Railroad (Fairfield, Washington: Ye Galleon Press, 1980). A photograph of the NP's 1882 Missouri River bridge appears on p. 80 of this volume.

6. Robinson, History of North Dakota, 143.

7. For a discussion of the role railroads played in town-building in northwest North Dakota and of the marketing hierarchy established throughout the region among small towns and large cities, see John C. Hudson, Plains Country Towns (Minneapolis: University of Minnesota Press, 1985) esp. Chapter 8, "Merchants and Trade Centers," 104-120. For a discussion of the transportation system developed throughout the region utilizing rails for trunks and branches and utilizing rural gravel roads as feeders, see John R. Borchert, America's Northern Heartland (Minneapolis: University of Minnesota Press, 1987), 44 and Chapter 3, "Mature Settlement System," 51-78. On railroads promoting good roads, see "Railways Promoting Good Roads," Literary Digest 45 (2 November 1912): 796.

8. Mercer County "Commissioner's Minute Book," Auditor's Office, Mercer County Courthouse, Stanton, Book 3, 20 May 1912, 128.

9. Several miles from the Fairview bridge, a second railroad lift bridge at Snowden, Montana also saw long-term vehicular use. See Quivik, Historic Bridges in Montana, 71.

10. Harold E. Briggs, "Early Freight and Stage Lines in Dakota," 229+.

11. David R. Vik, "Early Bridges of Moorhead and Fargo, 1871-1893" (M.S. thesis, Moorhead State University, 1984).

12. Robert L. Carlson and Larry J. Sprunk, History of the North Dakota State Highway Department (Bismarck, North Dakota State Highway Department, 1979), 8.

13. Ibid., 10.

14. Section 1051, Chapter 17, of The Revised Codes of the State of North Dakota, 1895.

15. These comments are drawn from a review of the county commissioners records in Burleigh, Griggs, Traill, and Ward and counties.

16. Fredric L. Quivik, "Montana's Minneapolis Bridge Builders," IA: The Journal of the Society for Industrial Archeology 10 (1984): 41-42.

17. Atlas of Minneapolis, Hennepin County, Minnesota, 1903 (Minneapolis: Minneapolis Real Estate Board, 1903) 44; Horace B. Hudson, A Half Century of Minneapolis (Minneapolis: Hudson Publishing Co., 1908); The Improvement Bulletin (2 January 1909): 3.

18. "Grand Forks County Commissioners Proceedings," Auditor's Office, Grand Forks County Courthouse, Grand Forks, North Dakota, Book 4, 3 April 1899, 258; Book 5, 2 April 1901, 29; 5 May 1902, 157; 6 April 1903, 278. Dunn County also seems to have purchased its own steel for bridges; see "Dunn County Commissioners Proceedings," Auditor's Office, Dunn County Courthouse, Manning, North Dakota, Book 2, 14 March 1917, 30.

19. Identification of an existing suspension foot-bridge crossing the Sheyenne River in Valley City and retaining a bridge plaque identifiying it as having been constructed by Dibley and Robinson in 1901 is provided in a "Memorandum" from James E. Sperry, SHSND to Kent N. Good, NDDOT, 7 February 1992.

20. These comments are derived from a review of county commissioners' minute books in a variety of North Dakota Counties (as listed in the bibliography). In addition to Foster County, other counties whose bridge work was dominated by Fargo Bridge & Iron include Eddy, Steele, Cavalier, Pembina, Walsh, Burleigh, Morton, Hettinger, McLean, Grant, Sargent, and Traill.

21. "J.A. Jardine, 72, Dies Here: Was President of Bridge Firm," The Fargo Forum, 15 September 1952, 7.

22. History of the Red River Valley (Chicago: C.F. Cooper & Co., 1909), 171; Lewis F. Crawford, History of North Dakota, II (Chicago: The American Historical Society, Inc., 1931) 7-8; "J.A. Jardine, 72, Dies Here: Was

President of Bridge Firm," The Fargo Forum, 15 September 1952, 7; "John B. Jardine Was Third of Family in Bridge Firm," The Fargo Forum, 30 October 1963, 18; "Dibley House," National Register of Historic Places Nomination, 6 June 1980, located at the State Historic Preservation Office, North Dakota Heritage Center, Bismarck. "McHenry County Commissioners Minutes," Auditor's Office, McHenry County Courthouse, Towner, North Dakota, Book 1, 6 April 1896, 267; 4 April 1898, 325; telephone interview with Nancy Jardine, 19 November 1991.

23. Herbert S. Schell, South Dakota Manufacturing to 1900 (Business Research Bureau, Vermillion, South Dakota: 1955), 74-75, makes this case for South Dakota, and the same would be expected for North Dakota. For example, in John Lee Coulter, Industrial History of the Valley of the Red River of the North (Bismarck: State Historical Society of North Dakota, 1910), it is quite clear that farming is the industry of early North Dakota.

24. Grand Forks County Heritage Book Commission, Grand Forks County Heritage Book (Dallas: Taylor Publishing Co., 1976); "Grand Forks County Proceedings of Board of Commissioners," Auditor's Office, Grand Forks County Courthouse, Grand Forks, North Dakota, Book 4, 6 April 1897, 32; 7 April 1898, 147; 3 April 1899; 2 April 1900; Book 5, 2 April 1901, 29; Book 6, 12 March 1907; 11 February 1908; City Directory of Grand Forks, North Dakota, and East Grand Forks, Minnesota (Grand Forks: The Plaindealer Company, Publishers, 1898), listing under Turner; Grand Forks City Directory (St. Paul: Pettibone Directory Co., 1903, 1907, 1916, and 1915), listings under Turner.

25. Ross, Nancy. "Burlington Northern Railroad Overhead Bridge: HAER No. ND-4." Historic American Engineering Record Documentation (May 1991).

26. Eli Woodruff Imberman, "The Formative Years of Chicago Bridge & Iron Company" (Ph.D. dissertation, University of Chicago, 1973) provides an extensive discussion of pooling. See especially 153-164, 173-176, 260-262, 267-269, 288. For a list of those bridge builders partaking in pooling arrangements from 1880-1897, see the appendix on 603-605.

27. These comments are derived from an analysis of the county commissioners records for Grand Forks and Walsh counties.

28. These comments are derived from a review of county commissioners records in Barnes, McHenry, and Stark counties.

29. These comments are derived from a review of county commissioners records in McKenzie and Ramsey counties.

30. Carl Larson, "A History of the Automobile in North Dakota," reprinted from North Dakota History 54 (Fall 1987): 1-21; J.E. Kaulfuss, "The State Highway System of North Dakota," Proceedings of the North Dakota Society of Engineers 5 (1921): 29-31.

Engineers 5 (1921): 29-31.

31. James J. Flink, America Adopts the Automobile, 1895-1910 (Cambridge: The MIT Press, 1970), 213.

32. "Good Roads Experiment Station" established by Chapter 133, Session Laws 1909; details of its accomplishments in "Brief Historical Review of State Highway Legislation in North Dakota," North Dakota Highway Bulletin 7 (August 1930): 8; A Brief History of the North Dakota State Highway Department (1939), 6; and Robert W. Holte, "History of the North Dakota State Highway Department" (Unpublished paper, September 1966), 14.

33. Thor G. Plomasen, "The County Superintendent of Highways System; and the County Roads," Proceedings of the North Dakota Society of Engineers 1 (1914): 89-92.

34. Fifth Biennial Report of the State Engineer to the Governor of North Dakota for the Years 1911-1912 (Fargo: Knight Printing Company), 43-45.

35. North Dakota State Wide Highway Planning Survey, Brief History, 2.

36. Carlson and Sprunk, History of the North Dakota State Highway Department, 34-35.

37. A review of records in several North Dakota counties revealed that counties rarely purchased road grading equipment before World War I.

38. North Dakota State Wide Highway Planning Survey, Brief History, 2; Holte, History of the North Dakota State Highway Department, 24.

39. Carlson and Sprunk, History of the North Dakota State Highway Department, 34.

40. North Dakota's Good Roads Magazine 2 (15 August 1922): 9-17.

41. Sixth Biennial Report of the State Engineer to the Governor of North Dakota for the Years 1913-1914 (Devils Lake: Journal Publishing Co., 1914).

42. Seventh Biennial Report of the State Engineer to the Governor of North Dakota for the Biennial Period Ending June 30, 1916 (Fargo: Walker Bros. & Hardy, 1916), 5.

43. Quote from interview by Larry Sprunk with George Dixon, May 17, 1978, State Highway Department Oral History Transcripts, Series 1049, Tape #16; information on early roads from John W. Dahlquist, "A Brief Historical Review of the Growth of the Highway System of North Dakota" (unpublished paper, 13 March 1930).

44. Guide to the National Archives of the United States (Washington: National Archives and Records Administration, 1987), 525-526.

45. National Highway Users Conference, "Federal Aid --- Federal Roads," report prepared in 1936, p. 9, in folder 38/109, Department of Transportation Collection, South Dakota Cultural Heritage Center, Pierre.

46. Report of State Engineer for July 1, 1920 to June 30, 1922 (Grand Forks: Normanden Publishing, 1922), 2257-2259.

47. J.E. Kaulfuss, "State Highway Plans and Work," Proceedings of the North Dakota Society of Engineers 4 (1919), 67.

48. J.E. Kaulfuss, "The Road Situation in North Dakota Reviewed," North Dakota Good Roads Magazine 2 (15 November 1922): 15-16; Fourth Biennial Report North Dakota State Highway Commission (1924), 10-13.

49. A Brief History (1939), 43-46.

50. J.E. Kaulfuss, "The Road Situation in North Dakota Reviewed," North Dakota Good Roads Magazine 2 (15 November 1922): 17.

51. For a discussion of the funding problems faced by the North Dakota State Highway Commission see: Fourth Biennial Report North Dakota State Highway Commission (1924), 10-13; Ninth Biennial Report of the State Engineer to the Governor of North Dakota (1920), 68-70; Twelfth Biennial Report of the Chief Engineer and Secretary of the State Highway Commission (1926), 9-10; E. O. Hathaway, "U.S. Bureau of Public Roads---History and Purpose," North Dakota Good Roads Magazine 2 (15 November 1922): 9-11; J. E. Kaulfuss, "The Road Situation in North Dakota Reviewed," North Dakota Good Roads Magazine 2 (15 November 1922): 15-17.

52. On the resolutions opposing federal aid, see Grand Forks Herald 25 February 1922, 10. For a sense of the local meetings held on the issues, see the series of articles in the Richland County Farmer and The Wahpeton Globe in early March 1922. On the arguments on both sides of the issue, see North Dakota Good Roads Magazine 1 (15 March 1922): 15-16, 18-20. On the fear of loosing local control, see North Dakota Good Roads Magazine 1 (June 1921): 14. On the "anti-good roads" movement elsewhere, see "Pro- and Anti-Road Campaigns," The Literary Digest (8 April 1922): 27-28.

53. Sixteenth Biennial Report of the Commissioner of University and School Lands, State of North Dakota, for the Period beginning July 1, 1922, and ending June 30, 1924, 5-6.

54. J.E. Kaulfuss, "The State Highway System of North Dakota," Proceedings of the North Dakota Society of Engineers 5 (1921): 29-31.

55. North Dakota Highway Bulletin 6 (September 1929): 3.

56. North Dakota Highway Bulletin 7 (January 1931): 5+.

57. North Dakota Highway Bulletin 8 (January 1932): 6-7.

58. North Dakota Highway Bulletin 8 (July 1932): 1.

59. Regarding the Hayden-Cartwright Road Act see the Annual Report of the Highway Commissioner of North Dakota to the Governor, 1933-1934, 7. Information about the diversion of funds is in North Dakota State Planning Board, Highway Report (1937), 5-6.

60. National Highway Users Conference, "Federal Aid -- Federal Roads: A Study of Federal Highway Legislation", 1 October 1936, 13, report in Folder 38/109, Class "N" Misc. 1936-37, Department of Transportation Collection, South Dakota Cultural Heritage Center, Pierre; John R. Stilgoe, Metropolitan Corridor: Railroads and the American Scene, (New Haven: Yale University Press, 1983) 361-367.

61. George R. Pasco, "Rock Bridge Construction by Relief Labor," Public Works 67 (September 1936): 49.

62. A number of published volumes provide good introductions to the historical evolution of bridge technology; some of the best are found in the published historic bridge surveys of various states. Volumes in this category include Clay Fraser, Colorado Bridge Survey (Loveland, Colorado: FraserDesign, n.d.); Steven R. Rae, et.al., New Mexico Historic Bridge Survey (Santa Fe: New Mexico State Highway and Transportation Department, 1987); James L. Cooper, Iron Monuments to a Distant Posterity: Indiana's Metal Bridges, 1870-1930 (n.p., 1987); Fredric L. Quivik and Lon Johnson, "Historic Bridges of South Dakota" (Pierre, South Dakota: South Dakota Department of Transportation, 1990); The Ohio Historic Bridge Inventory Evaluation, and Preservation Plan (Columbus: Ohio Department of Transportation, 1983); and Dwight A. Smith, et.al., Historic Highway Bridges of Oregon (Salem: Oregon Department of Transportation, 1986). For a more lengthy discussion, see David Plowden, Bridges: The Spans of North America (New York: Viking Press, 1974). Unless otherwise referenced, material in this chapter is drawn from pages 4-13 of the Fraser volume.

63. Fraser, Colorado Bridge Survey, 5-6. Also see Smith, et.al., Historic Highway Bridges of Oregon, 19-21.

64. An excellent description of the varied types of highway truss bridges is found in Chapters 3, 5, and 6 of Cooper, Iron Monuments to Distant Posterity.

65. Ibid., 47-49.

66. Charles Evan Fowler, "Some American Bridge Shop Methods," Cassier's Magazine 17 (Januar66.y 1900): 200-215.

67. 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).

68. Milo S. Ketchum, The Design of Highway Bridges (New York: McGraw-Hill Book Company, 1912), 389.

69. "McHenry County Commissioners Proceedings," Auditor's Office, McHenry County Courthouse, Towner, North Dakota, Book 2, 8 July 1905, 383.

70. "Richland County Commissioners Record," Auditor's Office, Richland County Courthouse, Wahpeton, North Dakota, Book E, 12 April 1907, 37.

71. Frahm quote on pp. 41-41 and Crabbe quote on p. 39 of Seventh Biennial Report of the State Engineer to the Governor of North Dakota for the Year Ending June 30, 1916 (Fargo: Walker Brothers and Hardy, 1916); Mountrail County Commission "Commissioners' Proceedings," Auditor's Office, Stanley, Book 2, 7 May 1917, 475.

72. Ramsey County "Commissioners Record," Auditor's Office, Ramsey County Courthouse, Devils Lake, Book C, 21 May and 18 June 1907, 377-379. For documentation of concrete bridge construction after 1907, see: Book C, 26 May 1908, 461; 20 May 1909, 586-587; Book D, 17 May 1910, 70; 31 May 1911, 203; Book E, 9 April 1912, 7; 12 March 1914, 81; 5 April 1915, 152; 4 April 1916, 207; 3 April 1917, 267; 8 April 1919, 360.

73. This comment is drawn from a review of the county commissioners records. For example, Bottineau County hired an engineer in 1911 to furnish plans and specifications for steel and concrete bridges.

74. Traill County "Commissioners' Proceedings," Auditor's Office, Traill County Courthouse, Hillsboro, Book B, 11 January 1884, 11.

75. See for example: Walsh County "Commissioners' Proceedings," Auditor's Office, Walsh County Courthouse, Grafton, Book G, 9 March 1910, 49: "Each bidder having a representative present."; McHenry County "Commissioners' Minutes," Auditor's Office, McHenry County Courthouse, Towner, Book 2, 11 July 1904, 257: "Adopt plans submitted by Fargo."

76. Charles C. Schneider, "The Evolution of the Practice of American Bridge Building," Transactions of the American Society of Civil Engineers 54 (1905): 224-225.

77. Ibid., 226-227.

78. Fifth Biennial Report (1912), 43-45; Seventh Biennial Report (1916), 33-34.

79. Seventh Biennial Report, (1916).

80. L.O. Marden, "State Highway Bridge Construction in North Dakota," Proceedings of the North Dakota Society of Engineers 5 (1921): 38. On state-sponsored concrete-arch bridge construction, see Robert M. Frame, III, "Reinforced-Concrete Highway Bridges in Minnesota, 1900-1945," unpublished National Register Multiple Property Documentation Form, 1988, Minnesota SHPO; Jeffrey A. Hess and Robert M. Frame III, Stone-Arch and Concrete-Arch Bridges of Wisconsin, Historic Highway Bridges in Wisconsin, vol. 1 (Madison: Wisconsin Department of Transportation, 1986), 235-259.

81. For information about concrete bridge construction in the state in the early 1920s, see L.O. Marden, "State Highway Bridge Construction in North Dakota," Proceedings of the North Dakota Society of Engineers 5 (1921): 38; and "North Dakota and Its Road Program," North Dakota Good Roads Magazine 1 (December 1921): 8. On state-sponsored concrete-arch bridge construction in other states, see note 1.

82. Twelfth Biennial Report (1926), 9-10.

83. Ibid., 37.

84. "Design Features of the Sorlie Memorial Bridge," Souvenir Historical Program, The Sorlie Memorial Bridge, 1929 (Grand Forks: Page Printing Company, 1929), n.p.

85. Twelfth Biennial Report Chief Engineer and Secretary of the State Highway Commission (1926).

86. Clifford Johnson, "Timber Bridges in North Dakota," North Dakota Highway Bulletin 7 (December 1931): 5-6; McKinnon speech reprinted in North Dakota Highway Bulletin 8 (January 1932):86. 6.

87. Ibid.

88. "End Bearings of Bridge Allow for Shifting of Abutments," Engineering News-Record 104 (29 May 1930): 898-900; "Souvenir Historical Program, The Sorlie Memorial Bridge 1929."

89. C.A.P. Turner, "Open-Well Piers and Subdivided Warren Trusses of Bismarck-Mandan Bridge," Engineering News-Record 88 (2 February 1922): 180-183.

90. Governor Sorlie quoted in North Dakota Highway Bulletin (May 1926): 5. Information about other bridges in the same publication in January 1926 (p. 6) and September 1929 (pp. 3-8). The quote concerning the major bridge projects is from "Biennial Report of Bridge Department," Biennial Report of the State Highway Commission for the Biennium Ending June 30, 1928, 2239-2240.

F. Associated Property Types

A. Introduction: Bridges and the National Register Evaluation Criteria[1]

This documentation form examines North Dakota roadway bridge construction for the period 1885 through 1946. According to National Register Bulletin No. 15, "How to Apply the National Register Criteria for Evaluation," to be eligible for listing in the National Register of Historic Places, a bridge must be significant in American history, architecture, engineering or culture, and possess integrity of location, setting, design, materials, workmanship, feeling, and association. In addition, the bridge must meet one or more of the four National Register Criteria:

A. be associated with events that have made a significant contribution to the broad patterns of our history; or

B. be associated with the lives of persons significant in our past;

C. embody the distinctive characteristics of a type, period, or method of construction, or that represent the work of a master, or that posses high artistic values, or that represent a significant and distinguishable entity whose components may lack individual distinction; or

D. have yielded, or may be likely to yield, information important in prehistory or history.

The specific means by which a bridge may meet each of the National Register Criteria are discussed below.

National Register Criterion A: Under Criterion A, a bridge may be eligible for the National Register through its association with historic themes. Applicable areas of significance for bridges as defined in National Register Bulletin 16 include:

- *Exploration/Settlement:* Bridges, especially early bridges, may have been associated in a meaningful way with the settlement or development of a geographically definable area. Larger bridges over major rivers may have significance for their historical associations with regional settlement or development.

- *Industry:* The design of bridges has been closely associated with the technology and process of producing new materials. Bridges associated with the development and introduction of new materials are important.

- *Politics/Government:* The construction of bridges has most often been undertaken by governmental bodies --- first townships, then counties, and later the state with federal regulations and financial inducements. Bridges may be significant if they represent important patterns in the methods counties awarded contracts or are associated with standardized state designs. Although, the State Engineer's office began providing bridge plans to the counties in 1913, it was not until 1926 that all bridge engineering work was finally taken over by the state. Other important bridges may be associated with the federal New Deal programs such as the Civilian Conservation Corps and the Works Progress Administration which were intended to create labor intensive jobs. The Hayden-Cartwright Act of 1934 was another New Deal program which placed a high priority on addressing the elimination of grade crossings.

- *Transportation:* Every bridge in North Dakota found eligible for listing in the National Register is associated with the "broad pattern" of transportation. Bridges may gain additional significance under this theme if they facilitated major passage to or through a region or played an important role in the development of an effective transportation system. Large bridges, especially the costly iron and steel through trusses, represent major investments on the part of counties to address the public's demand for adequate transportation routes.

<u>National Register Criterion B</u>: Under Criterion B, a bridge may be eligible for the National Register if a historically significant person's importance relates directly to the structure. Since the National Register's guidelines state that properties significant as an important example of an engineer's skill should be nominated under Criterion C, it is rare that a bridge would be found eligible under Criterion B.[2] It is conceivable, however, that a bridge might have played a pivotal role in the career of an important politician or other civic leader who, perhaps, advocated its construction.

National Register Criterion C: Under Criterion C, a bridge may be eligible for the National Register if it embodies "the distinctive characteristics of a type, period, or method of construction, or represents the work of a master, possesses high artistic value, or represents a significant and distinguishable entity whose components may lack individual distinction." The only applicable area of significance for bridges under this criterion from Bulletin 16 is in the category of engineering.[3]

The design and popular use of bridge types has been closely tied to the development of new materials and an understanding of their use. Bridges can provide excellent illustrations of the changes that have occurred in metal and concrete technologies. Some bridges may be significant as rare examples of a type, either as design experiments or widely accepted types that are no longer common. Other bridges, by their ubiquity, are significant as representative examples of a commonly used type and method of construction. Engineers also added aesthetic details, such as decorative balustrades, to some bridges which increase their significance beyond the pure mathematical application of the science.

National Register Criterion D: Under Criterion D, a bridge or its remains may be eligible for the National Register if it can yield important information about bridge technology or construction. The information should be embodied in the bridge or its remains; the mere existence, or former existence, of a bridge at a particular location does not constitute sufficient important information. Furthermore, the information should not be available through other sources, such as historical documents or extant bridges. Prior inventories of North Dakota highway bridges have identified no properties that meet this criterion.

B. Property Types

I. Name of Property Type: Metal Highway Truss Bridges

II. Description:

This property type includes those bridges constructed of a metal framework superstructure (the truss), over or through which the roadway passes. The framework is comprised of individual members assembled in a prominent geometric pattern of solids and voids. Each individual member consists of metal structural shapes of various sizes and configurations, used both individually and in combination with each other.

The bridges in this property type are built of metal, either iron or steel. While it requires a metallurgical analysis to ascertain conclusively whether a bridge is constructed of iron or steel (or is comprised of both iron and steel members), the date of construction can be a fairly reliable guide. Wrought iron was the standard material for most bridge trusses in the 1870s and 1880s. There was a brief transitional period in the early 1890s, after which steel became the material of choice. In North Dakota, the single surviving truss bridge built in the 1880s represents a rare surviving example of the once common use of iron. Truss bridges built between 1890 and 1895 may be constructed of iron, steel, or a combination of the two materials.[4] Truss bridges constructed from 1895 to 1900 represent the introduction of steel truss design to North Dakota.

Metal truss types receive their names from the configuration of the truss members. In most cases, the name for each truss type comes from the person or company that developed it. The only metal truss types found in North Dakota highway bridges are the Pratt and the Warren.

Pratt trusses are characterized by vertical members which, because they are designed to be in compression when under load, are relatively thick and visually prominent. On the other hand, diagonal members function in tension, and are thus relatively thin. Pratt trusses have horizontal upper chords. There are several sub-varieties of the Pratt truss, but the only one represented in North Dakota is the Parker truss. The Parker truss, while having vertical compression members and diagonal tension members, is characterized by a polygonal upper chord. Nationwide, and in North Dakota, Pratt trusses were widely used from the late 1800s until the mid 1910s, although they continued to be built into the 1920s. The Parker truss came into general usage during the 1920s; its design was suited to longer spans, reaching lengths in North Dakota from 200 to 300 feet.

Warren trusses are characterized by diagonal members which function in both tension and compression, and therefore are relatively thick. The diagonal members form a "W" pattern along the length of the truss. Warren trusses often also have vertical members, which are usually thinner than the diagonals. Warren pony trusses became increasingly popular in the early twentieth century, and by the 1910s had supplanted the Pratt as the most commonly built type of pony truss. Three variations on the basic Warren truss design were identified in North Dakota: a double-intersecting Warren Pony truss, in which the diagonal members overlap; Warren Pony trusses with a polygonal upper chord; and a sub-divided Warren through truss with polygonal upper chord, designated a "Warren-Turner" truss by its designer.

Within each truss type, bridges are usually divided into three categories based on the location of the deck: (1) through truss bridges, (2) pony truss bridges, and (3) deck truss bridges. In a through truss, the deck, or roadway, is located at or near the bottom chord and vehicles pass between the truss members. A pony truss is identical to a through truss in the location of the deck, but is low enough not to require overhead lateral bracing. In a deck truss, the deck, or roadway, is carried on the top chord. Site conditions usually determined which type of bridge would be used. Pony and through truss bridges were generally selected when there was relatively little difference between the level of the road and the level of the water. Deck truss bridges were used where that elevation difference was great, such as when a bridge was needed to carry a road over a deep gorge. In North Dakota, pony trusses served relatively short spans (usually from 40 to 80 feet) and through trusses served longer spans (usually 80 to 100 feet). No deck truss bridges were located in North Dakota, and they are not included in the discussion of this property type.

Metal truss bridges are further categorized based on the way the bridge's structural members are connected. During the nineteenth century, most iron and steel truss bridges were pin-connected. Pins set through holes held members together at each intersection of vertical, diagonal, and chord members. Around the turn of the century, bridge designers and builders began to make greater use of riveted connections, especially for short-span bridges. The vertical, diagonal, and chord members were riveted to a steel gusset plate at their intersection. At times, sections of a truss were riveted in a fabricating shop and then bolted together in the field. By the 1920s, the riveted connection replaced pins in almost all new bridges.

Trusses of the same type (for example, the pin-connected Pratt through truss) exhibit subtle differences in certain details, such as portal bracing, composition of built-up members, and floor beam connections. To date, however, it is not possible to draw a direct correlation between these various characteristics and the different builders or fabricators. Similarly, beyond the knowledge of the general popularity of particular types, connections, and details, it is not possible to date bridges this way.

Although the superstructure is the most significant aspect of bridges in this property type, the substructure is also important. Nationally, the earliest bridges in this property type were built with stone abutments and stone piers. In North Dakota, the most common substructure for early through trusses consisted of concrete-filled tubular caissons of riveted iron or steel plate. Pairs of these caissons served as piers under the main span(s) and were typically accompanied by short, timber stringer approach spans. Abutments in these cases were usually wood piles with plank backwalls. Pony trusses, being lighter and shorter, most often rested on wood piles with plank backwalls, although some counties did specify tubular caissons. Around 1910, most counties were specifying either steel piles or concrete abutments.

III. Significance

Within the general guidelines for significance of North Dakota highway bridges established in the introduction to the property types section, the following metal truss bridge specific information is added:

Criterion A: Out-of-state fabricators and contractors are important to the early history of North Dakota bridge building for introducing iron and steel bridge technologies. Bridges associated with these companies are rare and thus have historical significance. The Wrought Iron Bridge Company of Canton, Ohio; C.P. Jones of Minneapolis; and the Gillette-Herzog Manufacturing Company of Minneapolis are the only nineteenth-century bridge fabricators and contractors with extant highway bridges in North Dakota.

Besides the out-of-state fabricators and contractors, two North Dakota companies are documented as having constructed metal trusses during the nineteenth century: Dibley and Robinson and Jardine and Anderson, both of Fargo. (None of their bridges from this period are known to have survived.) Dibley and Robinson, later under the name of the Fargo Bridge and Iron Company, went on to dominant bridge construction in North Dakota well into the twentieth century. Because the Fargo Bridge and Iron Company utilized materials and designs provided and proven elsewhere, the company's significance comes from the high level of control they maintained in the North Dakota bridge market.

A number of smaller, local companies also successfully competed for North Dakota bridge contracts. Bridges constructed by these builders are significant representations of the ability of local companies to compete successfully against the larger bridge building companies.

A noteworthy pattern of bridge contract awards was identified in many North Dakota county records. Even though the commissioners would advertise for competitive bids for bridge construction, one bridge building company would submit the low bid year after year. This was probably a form of collusion called "bridge pooling" which was a common practice throughout the United States.

Criterion C: The Pratt and the Warren are the only major known truss types represented in North Dakota's inventory of surviving metal historic bridges. Because the basic forms of these two truss types exist in relatively high numbers, representative examples should be selected for listing in the National Register. National Register Bulletin 15 states that a "structure is eligible as a specimen of its type or period of construction if it is an important example (within its context) of building practices of a particular time in history." Within those guidelines, the oldest and the longest metal trusses within each county are significant. The oldest surviving bridges show the earliest extant use of the technology; the longest spans reflect maximum limits of the technology.

The Pratt truss, both in through and pony truss configurations, was the most common metal truss type constructed in North Dakota during the late nineteenth century and the first decade of the twentieth century. Pratt trusses are, therefore, important representatives of a once common type. Because Pratt trusses remain in relatively high numbers, important representative examples should be selected for listing based on age and length.

The riveted Parker truss is a sub-category of the Pratt, and in North Dakota, dates almost exclusively from the 1930s. Since Parkers were most often used to cross major rivers, such structures should be evaluated for their engineering significance.

The Warren truss is the only other truss type represented in North Dakota. The riveted Warren pony trusses gained general acceptance about 1910, and quickly became the most commonly constructed truss type. Warren pony trusses are, therefore also important representatives of a common type. More Warrens than Pratts survive today, most likely due to their later date of construction. Important representative examples of riveted Warren pony trusses should be selected for listing based on age and length. Variations on the basic riveted Warren pony truss design and Warren through trusses are rare in North Dakota.

IV. Registration Requirements

The period of significance for this property type is from 1885 (the construction date of North Dakota's oldest known surviving bridge) to 1946 (the fifty-year "cutoff" point for National Register eligibility).

National Register Criterion A: A metal truss bridge in North Dakota may be eligible for listing in the National Register under Criterion A if it was or is:

1. An Important Crossing of a Major Waterway. Bridges of this type are often large spans which display noteworthy engineering designs as well. Construction of such bridges frequently stimulated the growth of the surrounding region.

2. Built by a Nineteenth-Century Bridge Fabricator. Several out-of-state bridge businesses, including the Wrought Iron Bridge Company of Canton, Ohio, the Gillette-Herzog Manufacturing Company of Minneapolis, and C.P. Jones of Minneapolis constructed bridges in North Dakota. These companies are important for introducing iron and steel bridge technologies to North Dakota.

3. Built Prior to 1926 by a North Dakota-Based Bridge Builder other than the Fargo Bridge and Iron Company. This survey identified several individuals and companies in North Dakota who constructed bridges in the state. They include: A.F. Turner of Grand Forks, Jardine and Anderson (also J.A. Jardine and M.S. Anderson independently) of Fargo, the LaMoure Construction Company of LaMoure, and the Nollman Lumber and Contracting Company (also Nollman and Brye and various other names) of Grafton. Because of the domination of bridge building in North Dakota by the Fargo Bridge and Iron Company and out-of-state bridge building companies, bridges built by these North Dakotans and their companies are important representations of attempts to compete with larger bridge building companies.

4. Built by a Bridge Building Company with an Established Period of Annual Contracts in a Particular County. In a number of North

Dakota counties, bridge companies received contracts over a successive period of years, even with, or under the pretense of, competitive bidding. This reflects an important pattern of bridge construction in North Dakota. To obtain a representative example of bridges associated with this pattern, the oldest bridge in each county with a long-term (a minimum of five years) bridge builder should be considered eligible.

5. Any Through Truss Bridge built prior to 1926 with a Documented Builder and/or Date of Construction. Such bridges represent significant investments on the part of the counties to expand and improve transportation networks.

National Register Criterion C: A metal truss bridge in North Dakota may be eligible for listing in the National Register under Criterion C if it was or is:

1. Built Prior to 1900. Bridges constructed prior to 1890 are most likely comprised of wrought iron. The period between 1890 and 1895 represents the transition from wrought iron to steel. Bridges built during this period may be wrought iron, steel, or a combination of both. Bridges constructed from 1895 to 1900 are most likely steel, and represent the earliest uses of the material in the state. Bridges from this time period are rare.

2. A Pony Truss Bridge Which is Not a Standard Pratt or Standard Warren Pony Truss design. Such bridges are rare and represent important design experiments.

3. A Through Truss Bridge Which is Not a Pratt or Parker. Such bridges are unusual in North Dakota and represent important design experiments or are the few remaining examples of a once popular type.

4. The Oldest Bridge in a County (prior to 1926). Bridges with documented dates of construction as the oldest in a county have local significance.

6. The Oldest Bridge of a Type in North Dakota. Types of bridges with documented dates of construction as the oldest in North Dakota have statewide significance.

7. The Longest Bridge of a Type in North Dakota. Such bridges represent engineering efforts to push a particular type to its limits, possibly to solve unusual site conditions. They have statewide significance.

V. Integrity

In addition to the requirement that a bridge must meet one or more of the National Register criteria to be considered eligible for listing in the National Register, it must also retain integrity. The integrity of each bridge is assessed through the following aspects:

Design: The most important parts of a metal truss bridge design are the configuration of the truss and the connections. A metal truss bridge retains integrity of design if it is capable of conveying these engineering features. A metal truss bridge has lost integrity of design if the spatial relationship between its members has been changed or the connections have been replaced with connections differing from those used historically.

Materials: A metal truss bridge retains integrity of materials if the superstructure retains materials original to the construction, replacement materials were installed during the period of historic significance, or modern repairs or replacements are the same type as those used during the period of significance. Materials include the individual and composite members and the connections. Because the superstructure is the most important feature of bridges in this property type, neither an original substructure nor an original deck and railing system are necessary for the bridge to be eligible (although these original components may add to the significance of the bridge). On the other hand, for a bridge in this property type to be eligible, replacement substructure or deck components must be of such scale and composition that they do not overwhelm or otherwise detract from a clear visual impression of the metal frame of the superstructure and its function.

Workmanship: The superstructures of bridges exhibit no workmanship because all of the materials used were mass-produced.

Setting and Location: Bridges which are eligible under Criterion A for their associations with an important crossing must have integrity of location. All other bridges may have been moved, but they should retain integrity of setting; i.e., they should still span a channel or body of water, railroad tracks, or some other barrier to vehicular travel. Physical and visual intrusions can diminish the integrity of setting and location, but do not in themselves, preclude eligibility unless the relationship of the bridge to the topographic feature which resulted in its construction has been destroyed.

Feeling and Association: These two aspects have equal effect on overall integrity. In general, the integrity of design, materials, and workmanship has a direct bearing on the integrity of feeling and association. Integrity of feeling and association of a bridge will be lost if modern materials are of such a scale and contrast to the remaining historic materials that the observer is more impressed by the alterations than the historic resource.

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

II. Description

This property type includes those bridges that use steel beams to span an opening or other obstruction. The beams may span between the abutments and piers or be anchored to the abutment and cantilever over a pier. The beams are either I-beams or built-up of steel plates and angle iron sections. In its simplest form, the I-beams and girders are spaced close enough together to carry the deck. In its most complicated form, the lower flange of the steel girder carries transversely-laid I-beams of a smaller depth. In this case, the roadway passes between the girders, and it is called a through girder bridge.

The I-beam is the structural steel shape which is most common today. The shape (two equal and flat flanges) was first employed in building construction prior to the Civil War. It was not until after the turn of the century, however, that I-beams gained general acceptance in bridge construction, primarily in short-span applications where timber stringers were formerly used. Through the 1910s, the relatively small I-beam sections available generally limited the use of steel stringer bridges to 40 feet; although bridge engineers recommended limiting their use to spans less than 30 feet.[5] As steel mills increased the depth of the I-beam through the 1920s, the maximum span of I-beam bridges also increased reaching 80 feet by 1928 (although 60-foot spans were considered the most efficient).[6] One of the most common uses of steel stringer bridges during the 1930s was to create grade crossings which separated highway and railroad traffic.

During the 1910s, steel girder bridges were recommended for use in urban areas to support the heavier loads; steel truss bridges remained more economical at the time for country roads.[7] Through the 1920s, steel girder bridges gradually gained acceptance over truss bridges, the main advantage being the protection of the structural members from errant vehicles. Limitations in field riveting capabilities and the maximum lengths of beams railroads could carry generally confined spans to about 100 feet until the 1930s.[8] Although the deck of most steel girder bridges rests atop the girders, two steel through girder bridges were identified in North Dakota.

Beginning in the late-1910s, engineers began refinement of the structural design of cantilevering. In cantilevered bridges, one end is anchored to the abutment and the other end extends over and beyond the pier. The reduction of dead load moments made the use of shallower beams possible.[9] In its most dramatic form, engineers applied the principle of cantilevering to metal truss bridges, but the same economies also applied to simple steel stringer and steel girder bridges.[10] Two cantilevered steel stringer bridges, both constructed in 1936, were identified in North Dakota.

III. Significance

Criterion A: Steel stringer grade separation bridges constructed in North Dakota after passage in 1934 of the Hayden-Cartwright Act are significant for their association with the national debate to eliminate accidents and deaths at railroad crossings and with an important New Deal program designed to address the problem. Grade separations in North Dakota are often quite visually impressive structures on the landscape, rising over long distances to reach the required height from the flat prairie.

Other New Deal programs, such as the Works Progress Administration and the Civilian Conservation Corps, also resulted in the construction of steel stringer bridges. Such programs were designed to improve the country's infrastructure, while employing laborers forced out of work by the widespread depression. Because these programs emphasized labor-intensive projects, the resulting bridges sometimes have aesthetic details such as stone abutments and decorative balustrades not typical of steel stringer bridge construction.

Criterion C: Although metal truss and concrete bridges attract the greatest attention in any bridge survey because of their visual prominence, the vast majority of bridges in the United States are short span steel stringer and steel girder bridges. The great number and unobtrusive similarity of bridges in this property type make it difficult to identify bridges with special significance. Evolution in design is limited mainly to the increased length of allowable spans in more recent years. Nevertheless, their use is associated with the important historical changes in industrial capacity which allowed the production of needed structural shapes and in their acceptance as a replacement for metal truss bridges.

Because of the large number of bridges in this property type and the lack of construction documentation, representative examples must be selected. National Register Bulletin 15 states that a "structure is eligible as a specimen of its type or period of construction if it is an important example (within its context) of building practices of a particular time in history." In selecting representative examples of steel stringer and steel girder bridges, the evaluation weighs additional characteristics, such as being the oldest example, the longest span, or exhibiting decorative details not found on similar bridges. The oldest surviving bridges show the earliest extant use of the technology; the longest spans reflect maximum limits of the technology. Decorative details are important expressions of aesthetic ideals and design concepts.

IV. Registration Requirements

The period of significance for this property type is from 1885 (the construction date of North Dakota's oldest known surviving bridge) to 1946 (the fifty-year "cutoff" point for National Register eligibility).

Within the general guidelines for significance of North Dakota highway bridges established in the introduction to the property types section, the following steel stringer and steel girder bridge specific information is added:

Criterion A: A steel stinger or steel girder bridge in North Dakota may be eligible for the National Register under Criterion A if it was or is:

1. A Grade Separation Bridge Constructed after Passage of the Hayden-Cartwright Act of 1934. These bridges are significant representations of the federal government's attempt to address the national problem of deaths and accidents at points where highways cross railroad lines. A documented date of construction is required.

2. Built under the Auspices of a New Deal Program. These bridges have important associations with the federally sponsored, labor-intensive work programs and sometimes display aesthetic details such as stone abutments and decorative balustrades not typical of steel stringer bridge construction.

Criterion C: A steel stinger or steel girder bridge in North Dakota may be eligible for the National Register under Criterion C if it was or is:

1. A Design of Aesthetic Merit. Most of North Dakota's steel stringer and steel girder bridges feature basic designs with angle iron or highway guard rails and concrete abutments or steel or wood piles. Variations from this standard design, such as balustrade railings or stone abutments, are significant for possessing aesthetic ideals or design concepts more fully than typical steel stringer bridges.

2. Any Steel Stringer or Steel Girder Bridge Which Exhibits Unusual Engineering Design. Variations on the basic design of steel stringer and steel girder bridges are unusual in North Dakota, therefore, cantilevered spans and through girders are significant.

3. Any steel stringer or steel girder bridge with a documented date of construction and/or builder. In comparison with truss bridges, most steel stringer and steel girder bridges are smaller and less conspicuous on the landscape. For this reason, they seldom display a builders' plaque or other construction information. Similarly, their small size makes their construction less likely to be recorded in historic documents. Steel stringer and steel girder bridges whose construction history is known are quite uncommon; those with such information are significant in documenting the historical and engineering lineage of steel stringer and girder bridge design and construction in the state.

4. The longest steel stringer and steel girder bridges in North Dakota. Since the evolution in design of this type of bridge is limited mainly to length, the longest examples have statewide significance.

V. Integrity

In addition to the requirement that a bridge must meet one or more of the National Register criteria to be considered eligible for listing in the National Register, it must also retain integrity. The integrity of each bridge is assessed through examination of design, materials, workmanship, feeling, association, setting, and location.

Design, Materials, and Workmanship: Because steel stringer and steel girder bridges are of such simple design, all of its features, including railings (if any) and abutments must be intact to convey its design features. A steel stringer and steel girder bridge retains integrity of design, materials, and workmanship if the structure retains materials original to the construction, replacement materials were installed during the period of historic significance, or modern repairs or replacements are the same type as those used during the period of significance. Materials include the stringers and girders, the railings, and the abutments. The original deck is not necessary for the bridge to be eligible.

Setting and Location: These two aspects have equal effect on overall integrity. The integrity of design, materials, and workmanship has a direct bearing on the integrity of setting and location. Steel stringer and steel girder bridges must be in the location where they were constructed. Physical and visual intrusions can diminish the integrity of setting and location, but do not in themselves, preclude eligibility unless the relationship of the bridge to the topographic feature which resulted in its construction has been destroyed.

Feeling and Association: These two aspects have equal effect on overall integrity. The integrity of design, materials, and workmanship also has a direct bearing on the integrity of feeling and association. Integrity of feeling and association of a bridge will be lost if modern materials cover the historic materials or are of such a scale and contrast to the remaining historic materials that the observer is more impressed by the alterations than the historic resource.

I. Name of Property Type: Concrete Highway Bridges

II. Description

This property type includes all of those highway bridges constructed of concrete. Five types of concrete bridges were identified in North Dakota: (1) slab; (2) girder; (3) T-beam, (4) arch, and (5) rigid frame. Concrete bridge design appropriated some forms, such as the arch and girder, which were utilized for bridges made of metal, stone, and other materials. Likewise, concrete T-beam bridges were an adaptation of the I-beam stringer. On the other hand, another common concrete bridge design, the slab, is feasible in that material alone.

Simple reinforced-concrete slab bridges were an alternative to steel or timber stringer structures. As the name implies, a slab span is cast in forms as a single unit with steel reinforcing bars. Because the design lacked other structural support, much reinforcing was required, making this type economical only for relatively short spans. There was frequent disagreement between early twentieth-century engineers about the optimal length for slab spans. As late as 1932, engineer John E. Kirkham maintained that slab bridges were economical "as a rule for spans not over 20 ft. in length." By the mid-1920s, however, others considered spans up to 30 feet to be appropriate. Given this debate between prominent engineers, it is difficult to use span length as a determinant of construction date, although it seems safe to assume that spans greater than 20 feet were probably built after the early 1920s. Slabs were usually constructed as simple spans, but by the 1920s designers began to experiment with continuous and cantilevered spans.[11] Early twentieth-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.

T-beam bridges copy the stringer style more directly. While the lower face of a slab is smooth, in a T-beam bridge concrete "stringers" provide additional support. These beams, usually flared where they meet the deck, give the style its name. The support of the beams allows for a thinner floor slab, reducing dead load and saving on material costs. Because of these design features, T-beam bridges could be used for longer spans than slabs, typically ranging from 20 to 55 long.

Concrete girder bridges, like their metal counterparts, are characterized by a pair of large girders edging the deck, sometimes fortified with one or more additional girders between. If the exterior girders are at or below the level of the roadway, the bridge is known as a deck girder. If the roadway travels between them, it is a through-girder bridge. Girder construction was typically used for spans from 30 to 50 feet long, but lengths ranging up to 80 feet were not uncommon.

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, usually not visually delineated on concrete bridges, is the extrados. If the extrados is highlighted by a molding or other ornament, the line is known as the archivolt. The triangular area buttressing the arch between the crown and the impost is the haunch. If the haunch is left unfilled in a concrete arch bridge, it is known as an open spandrel design; if filled, a closed spandrel. Most frequently, the bridge deck rests on top of the arch. Special patented designs popular in the early twentieth century, however, such as the Marsh rainbow arch, use a through-arch configuration.

Rigid frame bridges are concrete slabs that are connected by steel reinforcing bars to their abutments and the entire bridge cast as one unit. The rigid frame concrete bridge was more economical than other types, due to the shallower depths required to carry live loads. They were first introduced into the United States during the 1920s and came into common use by the 1930s.[12] The one rigid frame bridge located in North Dakota was designed by the Northern Pacific Railroad to carry its tracks over a highway.

Workmanship and detailing on concrete bridges vary widely. Because concrete is an extremely malleable material, it can be cast in many forms. Virtually the only obvious design element in the vast majority of concrete bridges is the railing. (An inspection of the underside of a concrete bridge is usually necessary to distinguish between girders, T-beams, and slabs.) Most of the surviving original railings on concrete bridges in North Dakota are standard designs typical throughout the Midwest from the 1910s onward. There were two main styles, each with two versions: solid concrete, with recessed or incised panels; and pipe rail, with concrete or pipe posts. These designs were used interchangeably on concrete girder, T-beam, and slab bridges. In rare instances, a Classical Revival balustrade or another ornamental design was featured, usually in a park or residential setting or for an important urban entryway.

III. Significance

Criterion A: The earliest documentation in the county records of concrete bridge construction in North Dakota is found in Ramsey County in 1907. In May of that year, the commissioners advertised for eight bridges: "bids to specify price for steel bridges and also of concrete and steel the same as the bridge built ... last year."[13] Several other counties in North Dakota began building concrete bridges during the early 1910s. Bridges from this period may have significance for expanding local transportation networks.

The ready availability of materials and the relative ease of using unskilled labor for the work encouraged concrete bridge construction under a variety of New Deal programs of the 1930s.[14] These bridges have important associations with the federally sponsored, labor-intensive work programs and sometimes display unusual aesthetic details such as decorative balustrades.

Criterion C: Many companies that erected steel truss bridges also bid on concrete bridges, presumably supplying their own plans for county work. Although the field was dominated by such larger companies as J.A. Jardine and the Fargo Bridge and Iron Company, small builders were also active, such as Wade Williamson of Mountrail County, to whom the commissioners "awarded the contract for the construction of all concrete, steel and pile bridges" in 1922.[15] Concrete bridges, with but some exceptions, received little attention in the county records.

Because of the large number of bridges in this property type and the lack of construction documentation, representative examples must be selected. National Register Bulletin 15 states that a "structure is eligible as a specimen of its type or period of construction if it is an important example (within its context) of building practices of a particular time in history." In selecting representative examples of concrete bridges, the evaluation weighs additional characteristics, such as being the oldest example, the longest span, or exhibiting decorative details not found on similar bridges. The oldest surviving bridges show the earliest extant use of the technology; the longest spans reflect maximum limits of the technology. Decorative details are important expressions of aesthetic ideals and design concepts.

Although not common in North Dakota, there were a few instances where the county commissioners or the public evidently felt that the setting called for a bridge with aesthetic appeal. These urban and park structures include false-arch bridge designs, such as the cantilevered T-beam in Minot, the two park bridges in Valley City, and the patented Marsh Rainbow arch in Valley City.[16]

IV. Registration Requirements

The period of significance for this property type is from 1885 (the construction date of North Dakota's oldest known surviving bridge) to 1946 (the fifty-year "cutoff" point for National Register eligibility).

Within the general guidelines for significance of North Dakota highway bridges established in the introduction to the property types section, the following concrete bridge specific information is added:

Criterion A: A concrete bridge in North Dakota may be eligible for listing in the National Register under Criterion A if it was or is:

1. Built as Part of an Important Early Transportation Route. There are few surviving examples of bridges associated with the initial development of the state's road system. Construction of

such bridges frequently stimulated the growth of the surrounding region.

2. Any Bridge Documented as being Constructed under a 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 bridges in the state.

Criterion C: A concrete bridge in North Dakota may be eligible for listing in the National Register under Criterion C if it was or is:

1. A Design of Exceptional Aesthetic Merit. Most of North Dakota's concrete bridges feature standard, straight-span designs with solid concrete or pipe rails. Variations from this standard design, such as balustrade railings, arch or false-arch forms, or stone facing, are significant for possessing aesthetic ideals or design concepts more fully than typical concrete bridges.

2. A Patented Design. Examples of these special designs, such as the Marsh Rainbow Arch, are extremely rare in North Dakota. They are significant for atriculating a particular concept of engineering design that expresses an aesthetic ideal.

3. Any Bridge with a Documented Builder and/or Date of Construction. It is difficult to ascertain who built most of the concrete bridges in North Dakota, or even when the bridges were built. In comparison with truss bridges, most concrete bridges are smaller and less conspicuous on the landscape. For this reason, they seldom display a builders' plaque or other construction information. Similarly, their small size makes their construction less likely to be recorded in historic documents. Concrete bridges whose construction history is known are quite uncommon; those with such information are significant in documenting the historical and engineering lineage of concrete bridge design and construction in the state. Known builders include F.M. Haas Company (Minot), Minneapolis Bridge Company

(Minneapolis), Jardine and Anderson (Fargo), and Dakota Concrete Products Company (Minot).

4. The Oldest Bridge of a Type in North Dakota. Types of bridges with documented dates of construction as the oldest in the state have statewide significance.

V. Integrity

In addition to the requirement that a bridge must meet one or more of the National Register criteria to be considered eligible for listing in the National Register, it must also retain integrity. The integrity of each bridge is assessed through examination of design, materials, workmanship, feeling, association, setting, and location.

Design: For a bridge in this property type to retain integrity of design, the concrete structural members must be substantially in their original condition, although alterations made during the period of significance (through 1942) may be considered part of the bridge's historic fabric. Since railings are such a key visible component of the design of a concrete bridge, the original railings must be substantially intact, unless the bridge has important engineering features (e.g. it is a rare example of a structural type or it approaches the engineering limits for its type) that bestow significance.

Materials: A concrete bridge retains integrity of materials if the structural materials and railings are original to the construction, replacement materials were installed during the period of historic significance, or modern repairs or replacements are the same type as those used during the period of significance.

Workmanship: In concrete bridges, workmanship is embodied in evidence of the builder's labor and skill in concrete construction demonstrated through precision, technique, and durability. Integrity of workmanship is lost if the original construction evidence is covered with later materials or aesthetic details such as the railings are removed.

Location and Setting: Since it is virtually impossible to move a concrete bridge and have it retain design integrity, bridges must be in their original location. The original setting of some urban and park concrete bridges affected their design selection. The construction of large buildings out of character with the historic setting or the removal of surrounding landscaping and natural features diminishes the integrity of setting. These bridges, however, usually display design features of such overriding importance that the loss of setting does not result in a loss of integrity.

Feeling and Association: These two aspects have equal effect on overall integrity of concrete bridges. The integrity of design, materials, workmanship, location, and setting also has a direct bearing on the integrity of feeling and association. Integrity of feeling and association of a bridge will be lost if modern materials cover the historic materials, the railings have been removed, or the bridge has been moved.

I. Name of Property Type: Timber Stringer and Timber Trestle Bridges

II. Description

This property type includes those bridges that use timber stringers to span an opening or other obstruction. Timber stringer bridges are distinguished from timber trestle bridges only in the substructure. Whereas the ends of the stringers of a timber stringer bridge rest on a single vertical support constructed of stone, concrete, or wood or steel piles, the stringers of a timber trestle bridge rest on a framework of vertical members joined together with horizonal and diagonal bracing.

Timber bridges are the oldest bridge type. From their humble origins as a few logs laid across a small stream or other barrier, designs evolved into complicated arch trusses by the early 1800s, reaching spans in excess of 200 feet.[17] Timber remained the most widely used bridge material throughout the nineteenth century as engineers experimented with combination trusses--timbers combined with wrought-iron, cast-iron, and steel members. The most common usage of timber, however, remained simple stringers with spans of around 15 feet. Longer bridges were built using multiple spans set on piers. These piers, however, were vulnerable to destruction by floods and ice and often required frequent replacement. This partly accounts for the ready acceptance of iron and steel stringer and truss bridges during the last two decades of the nineteenth century with their longer spans for wider barriers. Nationwide, by 1900, timber bridges were most often used to span the smaller, less challenging barriers.

Nationally, local governments were making wide use of iron and steel for through trusses in the 1890s, and in some cases, they began building metal pony trusses where shorter spans were needed. During the first two decades of the twentieth century, timber bridges all but disappeared as steel trusses, especially pony trusses, and steel stringers were adopted for "permanent" construction. By 1912, Milo Ketchum, one of the leading bridge engineers in the United States stated:

> Timber was formerly quite generally used in construction of highway bridges, and is still used for temporary structures in locations where timber is cheap and iron and steel are relatively expensive.[18]

The late 1920s saw a resurgence of timber stringer bridge building nationwide. Clifford Johnson, North Dakota Bridge Engineer, explained "that the so-called permanent bridges are not always permanent, and that timber bridges are not always short lived or temporary." Timber bridges of this period, however, did last longer than those used earlier due to the treatment of the wood with preservatives. As late as 1915, the majority of plants in the United States capable of treating wood were owned by the railroads. None of the plants was located in North Dakota.[19]

The use of wood bridges during this period was limited to timber stringers; by the 1920s, timber trusses were not competitive with steel trusses. Given load limits during that period, the maximum span for a timber stringer bridge was about 40 feet. In addition to initial materials cost, timber bridges offered several other advantages. They could be constructed quickly under any weather conditions. They could be moved, expanded, and repaired rather easily. If demolition was later necessary, salvage value for the timbers was relatively high.[20]

III. Significance

Criterion A: The North Dakota State Highway Department began advancing the use of timber stringer bridges in 1928. After years of being used for temporary construction or in remote locations, a re-evaluation of their expected lifespan, largely based on their initial cost, found them to be viable alternatives to other types of bridges. Timber stringer bridges designed by the North Dakota State Highway Department are significant representatives of this national and state pattern.

Criterion C: Timber stringer bridges are simple structures and display little engineering significance. As a result, it is difficult to make a case for significant associations with engineers or contractors. Engineers used already existing tables for maximum span lengths based on load requirements; contractors constructed the specified bridges. Because of the large number of bridges in this property type and the lack of construction documentation, representative examples must be selected. National Register Bulletin 15 states that a "structure is eligible as a specimen of its type or period of construction if it is an important example (within its context) of building practices of a particular time in history." To establish a representative sample of timber stringer bridges, any bridge with construction documentation which retains integrity of design should be considered in establishing significance under Criterion C.

The remaining timber trestle bridges in North Dakota either provide a railroad crossing over a highway or carry low-density county roads over railroad lines. These bridges were most likely owned and designed by railroad engineers, and have come into the ownership of the counties or state in later years. In most cases, research on these bridges would need to be conducted in the various railroad archives to establish significance. They do, however, represent the railroad bridge design for grade separations at various locations along their lines.

IV. Registration Requirements

The period of significance for this property type is from 1885 (the construction date of North Dakota's oldest known surviving bridge) to 1946 (the fifty-year "cutoff" point for National Register eligibility).

Within the general guidelines for significance of North Dakota highway bridges established in the introduction to the property types section, the following timber stringer and timber trestle bridge specific information is added:

Criterion A: A timber stringer or timber trestle bridge in North Dakota may be eligible for listing in the National Register under Criterion A if it was or is:

1. A Bridge Documented as having been designed by the State Highway Department after 1928. These bridges have significance for their association with the acceptance of timber stringer bridges by the State Highway Commission after careful study and consideration.

Criterion C: A timber stringer or timber trestle bridge in North Dakota may be eligible for listing in the National Register under Criterion C if it was or is:

1. Any timber stringer or timber trestle bridge with a documented date of construction and/or builder. It is difficult to ascertain who built most of the timber stringer and timber trestle bridges in North Dakota, or even when the bridges were built. In comparison with truss bridges, most timber stringer and timber trestle bridges are smaller and less conspicuous on the landscape. For this reason, they seldom display a builders' plaque or other construction information. Similarly, their small size makes their construction less likely to be recorded in historic documents. Timber stringer and timber trestle bridges whose construction history is known are quite uncommon; those with such information are significant in documenting the historical and engineering lineage of timber bridge design and construction in the state.

2. The oldest timber stringer and timber trestle bridges in North Dakota. Bridges with documented dates of construction as the oldest examples have statewide significance.

3. Representative Examples of timber stringer and timber trestle bridges. Since few timber stringer and timber trestle bridges are represented through other registration requirements, examples based on integrity of design or unusual features should be selected.

V. Integrity

In addition to the requirement that a bridge must meet one or more of the National Register criteria to be considered eligible for listing in the National Register, it must also retain integrity. The integrity of each bridge is assessed through examination of design, materials, workmanship, feeling, association, setting, and location.

Design, Materials, and Workmanship: Because timber stringer and timber girder bridges are of such simple design, all of their features, including railings (if any) and abutments must be intact to convey its design features. The loss of railings may be outweighed if the bridge displays unusual aesthetic merit. A timber stringer and timber trestle bridge retains integrity of design, materials, and workmanship if the structure retains materials original to the construction, replacement materials were installed during the period of historic significance, or modern repairs or replacements are the same type as those used during the period of significance. Materials include the stringers and girders, the railings, and the abutments. The original deck is not necessary for the bridge to be eligible.

Setting and Location: These two aspects have equal effect on overall integrity. The integrity of design, materials, and workmanship has a direct bearing on the integrity of feeling and association. Timber stringer and timber trestle bridges must be in the location where they were constructed. Physical and visual intrusions can diminish the integrity of setting and location, but do not in themselves, preclude eligibility unless the relationship of the bridge to the topographic feature which resulted in its construction has been destroyed.

Feeling and Association: These two aspects have equal effect on overall integrity. The integrity of design, materials, and workmanship also has a direct bearing on the integrity of feeling and association. Integrity of feeling and association of a bridge will be lost if modern materials cover the historic materials or are of such a scale and contrast to the remaining historic materials that the observer is more impressed by the alterations than the historic resource.

Endnotes for Section "F"

1. All references to National Register Bulletin 15 in the "Property Types" section are from: Department of the Interior, National Park Service, Bulletin 15: How to Apply the National Register Criteria for Evaluation ([Washington, D.C.: U.S. Government Printing Office, 1991); All references to National Register Bulletin 16 are from: U.S. Department of the Interior, National Park Service, Bulletin 16: Guidelines for Completing National Register of Historic Places Forms (1986) and the "Supplement" of 1987.

2. In addition to National Register Bulletins 15 and 16, see: U.S. Department of the Interior, National Park Service, National Register Bulletin 32, Guidelines for Evaluating and Documenting Properties Associated with Significant Persons, no pulbication information.

3. All other areas of potential significance for bridges appear, at least at this time to to relate to National Register Criterion A.

4. J.A.L. Waddell, Bridge Engineering (New York: John Wiley & Sons, Inc., 1916), 20-21; Charles C. Schneider, "The Evolution of the Practice of American Bridge Building," Transactions of the American Society of Civil Engineers 54 (1905): 218, 222.

5. Milo S. Ketchum, Structural Engineers' Handbook (New York: McGraw-Hill Company, 1914), 118.

6. Josef Sorkin, "Design of Highway I-Beam Bridges; Simple, Continuous and Cantilever Spans," Civil Engineering Thesis, University of Nebraska, 1936.

7. Milo S. Ketchum, Structural Engineers' Handbook, 118.

8. Carl W. Condit, American Building Art (New York: Oxford University Press, 1961), 99-100; Wilson G. Harger and Edmund Bonney, Handbook for Highway Engineers I (New York: McGraw-Hill Book Company, Inc., 1927), 209.

9. Harger, 169.

10. George A. Hool and W.S. Kinne, eds., Movable and Long-Span Steel Bridges (New York: McGraw-Hill Book Company, Inc., 1943), 256-288a.

11. Quote from John E. Kirkham, Highway Bridges: Design and Cost (New York: McGraw-Hill, 1932), 114. Other contemporary engineering publications dealing with concrete bridge design include Frederick W. Taylor and Sanford E. Thompson, A Treatise on Concrete Plain and Reinforced (New York: John Wiley & Sons, 1917 [copyright 1916]); Milo S. Ketchum, The Design of Highway Bridges of Steel, Timber and Concrete, 2nd ed., rewritten (New York: McGraw-Hill, 1920); Clement C. Williams, The Design of Masonry Structures and Foundations (New York: McGraw Hill, 1922); George A. Hool and W.S. Kinne, eds., Reinforced Concrete and Masonry Structures (New York: McGraw-Hill, 1924); and Frederick W. Taylor, Sanford E. Thompson, and Edward Smulski, Reinforced Concrete Bridges (New York: John Wiley & Sons, 1939).

12. Condit, 213-214; Robert M. Frame III, "A Historic Context for Minnesota Reinforced-Concrete Highway Bridges, 1900-1945," 1 April 1988, 20-22.

13. Ramsey County "Commissioners Record," Auditor's Office, Ramsey County Courthouse, Devils Lake, Book C, 21 May and 18 June 1907, 377-379.

14. J.W. Harty, "A Well Organized County Bridge Modernization Program," 24-26.

15. North Dakota Good Roads Magazine 2 (15 May 15 1922): 9.

16. For information about concrete bridge construction in the state in the early 1920s, see L.O. Marden, "State Highway Bridge Construction in North Dakota," Proceedings of the North Dakota Society of Engineers 5 (1921): 38; and "North Dakota and Its Road Program," North Dakota Good Roads Magazine 1 (December 1921): 8. On state-sponsored concrete-arch bridge construction in other states, see note 1.

17. Thomas Tredgold, Elementary Principles of Carpentry; A Treatise of the Pressure and Equilibrium of Timber Framing, etc. (London: The Architectural Library, 1828), 129.

18. Milo S. Ketchum, The Design of Highway Bridges, 389.

19. Howard F. Weiss, The Preservation of Structural Timber (New York: McGraw-Hill Book Company, Inc., 1915), 255-258.

20. Ibid.

G. Geographical Data

This nomination applies to properties located within the present boundaries of the State of North Dakota.

H. Summary of Identification and Evaluation Methods

This Multiple Properties Nomination is a primary product of two distinct research and field survey projects: a statewide field inventory and context development for North Dakota highway bridges conducted between 1989 and 1992; and a 1996 review of the earlier material, which culminated in the preparation of this document and approximately thirty individual National Register nominations. Each of these phases is discussed separately below.

1. Initial field survey and context development: Much of this document is based on an intensive survey of potentially historic highway bridges in the state of North Dakota. This survey was conducted between 1989 and 1991 under the sponsorship of the North Dakota Department of Transportation (NDDOT). Work on the project was contracted to a joint venture of two cultural resource consulting firms: Renewable Technologies, Inc. (RTI), of Butte, Montana, and Hess, Roise, and Company of Minneapolis, Minnesota. The project consultants completed an intensive field survey of over 400 historic bridges in the state, and also completed substantial primary and secondary research related to the history of North Dakota bridges.

The 1989-91 project was conducted in two phases. The first phase, largely conducted during 1989, included extensive background research on the history of the state's roadway bridges, a sampling of county-specific bridge research, and the compilation of a list of potentially historic roadway bridges in the state worthy of more intensive examination. Phase 2 of the project (1990-91) included substantial bridge-specific fieldwork and research, and culminated in the completion of site forms for approximately 400 North Dakota bridges as well as a comprehensive overview document ("Historic Bridges in North Dakota" [1992]). Much of the material in this documentation form is drawn from the 1992 overview, which was written by Mark Hufstetler, Frederic Quivik, and Lon Johnson of Renewable Technologies, Inc., and Charlene Roise of Hess, Roise & Company. The overview included a detailed synthesis of the evolution of bridge construction in North Dakota, as well as sections identifying relevant property types and discussing registration requirements.

A wide variety of research sources were consulted during first phase of the 1989-91 project, some of which were reviewed in the preparation of this document. Significant primary source materials are located in the Bridge Department of NDDOT. Included are computerized listings of bridges statewide, indicating year of construction and general structural type. Each individual bridge is also recorded on one or more Structure Inventory & Appraisal (SI&A) forms, which provide additional contemporary detail and occasional historic information. Further research was conducted at the Archives of the State Historical Society of North Dakota. Among the variety of primary source materials reviewed there were annual and biennial reports of the State Engineer's Office, issues of the state-published <u>North Dakota Highway Bulletin</u>, and the <u>North Dakota Good Roads Magazine</u>, published by the state's Good Roads Association.

Secondary sources about the evolution of the highway department include a seminal study dating from 1930, "A Brief Historical Review of the Growth of the Highway System of North Dakota," by John W. Dahlquist. This is a basis for two subsequent histories: <u>A Brief History of the North Dakota State Highway Department to January 1st, 1939</u> (funded by the Works Progress Administration), and Robert W. Holte, "History of the North Dakota State Highway Department" (1966). Other secondary sources reviewed included a variety of academic and engineering journals, bridge inventories of neighboring states, as well as broader statewide and regional histories. The most useful volume in the latter category is Elwyn B. Robinson's <u>History of North Dakota</u> (Lincoln: University of Nebraska Press, 1982).

Following the completion of Phase I research and the draft context, a list of bridges appropriate for field inventory and bridge-specific historical research was prepared. This list was prepared by applying the registration requirements contained in the context to a list of all known public roadway bridges in the state. This resulted in a final tally of some 471 bridges. During Phase II of the project, each bridge was visited, field-documented, and photographed. The survey confirmed that 403 of the bridges survived and retained integrity in 1991.

In counties with bridges included in the field survey, the minutes of the county commissioners were reviewed to obtain bridge-specific historical data. Unfortunately, the quality of these records varies significantly; information was not found on all bridges, and some information that was obtained was vague or incomplete. Information found here generally included only county-built (rather than state-sponsored) bridges. County records also helped reveal general bridge construction patterns within each county such as methods of awarding contracts, bridge builders, and changes in bridge technology. Newspapers, as well as local published histories were also reviewed, although they usually provided only limited information on a select number of bridges.

A final source of historical data is the bridge itself. Some bridges retain their original plaques identifying builder and date. The actual design of each bridge is also revealing, since each design tends to have an historical association with a certain period.

Once the field survey was completed, North Dakota Cultural Resources Survey forms were completed for each bridge. Then, each bridge was evaluated for eligibility for listing in the National Register of Historic Places using the registration requirements and aspects of integrity developed for the property types. A total of 127 bridges met the characteristics defined for eligibility.

2. 1996 field review and National Register nominations: In January 1996, the State Historical Society of North Dakota (SHSND) issued a Request for Proposals for the development of a Multiple Properties Documentation Form encompassing North Dakota's historic roadway bridges, as well as for

the National Register nomination of a number of the state's significant individual bridges. The material accumulated during the 1989-91 survey was to be used as a basis for developing these products. SHSND subsequently contracted with Renewable Technologies, Incorporated for the preparation of these products. RTI agreed to complete thirty individual nominations to accompany the Multiple Properties form.

RTI's work under this project was performed by Mark Hufstetler, a member of the firm's professional staff and a co-author of the 1989-91 study. Hufstetler began work on the project on April 15, 1996, with a field visit to North Dakota. In consultation with SHSND representatives, Hufstetler prepared a working list of forty bridges suitable for individual National Register nominations as part of the Multiple Properties submittal; records for these bridges at SHSND and NDDOT were reviewed to update the 1989-91 information. After research was completed, Hufstetler attempted to visit each of the bridges on the working list. Three were inaccessible due to road conditions, and one had been demolished; the remaining thirty-six were extant and retained integrity. Each of these bridges was rephotographed, and additional descriptive notes were compiled. Hufstetler selected thirty of these bridges for individual nomination, subject to SHSND approval.

Using the 1989-91 research materials, supplemented by 1996 research, Hufstetler prepared this Multiple Properties form and the individual nominations during the summer of 1996. All products were submitted to SHSND in September 1996.

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