NPS Form 10-900-a OMB No. 1024-0018
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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

High Pratt-Truss Highway Bridges of New Hampshire 1890-1945

B. Associated Historic Contexts

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

Developmental Overview of the High Pratt Truss in New Hampshire
Good Roads Movement, State of New Hampshire (1880-1910)
Development of the New Hampshire Highway Department, State of New Hampshire (1905-1945)
Floods of 1927 and 1936, State of New Hampshire (1927-1937)

C. Form Prepared by

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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 and Guidelines for Archeology and Historic Preservation. (See continuation sheet for additional comments.)

Signature and title of certifying official Date

State or Federal agency and bureau

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

Signature of the Keeper Date of Action

High Pratt Truss Highway Bridges of New Hampshire, 1890-1945 New Hampshire
Name of Multiple Property Listing) State

Table of Contents for Written Narrative

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

Page Numbers

E. STATEMENT OF HISTORIC CONTEXTS

Introduction

In the early years of the twentieth century, steel High Pratt truss bridges outnumbered every other truss design used in the United States, and may have outnumbered all other truss designs combined. Today, because of continual replacement, pre-1900 Pratt highway trusses have become rare and early twentieth century Pratt highway trusses in New Hampshire are being bypassed or replaced at a rapid pace. This Multiple Property Documentation Form is being prepared to provide a historic context on High Pratt Trusses of New Hampshire in order to lay the groundwork for identifying bridges that are eligible for listing in the National Register of Historic Places. In conducting background research, four themes or contexts emerged related to High Pratt truss bridge development. These include the Developmental Overview of the High Pratt Truss in New Hampshire; Good Roads Movement, State of New Hampshire (1880-1910); Development of the New Hampshire Highway Department (1905-1945); and Floods of 1927 and 1936, State of New Hampshire (1927-1937). An investigation of each context is found below.

Developmental Overview of the High Pratt Truss in New Hampshire

A truss is a beam constructed of numerous short, lightweight members for the purpose of spanning a distance greater than structurally or economically possible with a single solid beam. The originator of the concept of a truss is unknown and dates back to ancient times when gable roofs were reinforced with tie beams, king posts and struts. At some point it was recognized that to be stable, a truss must be composed of triangles, since the triangle is the only polygon whose form cannot be changed without altering one or more of its sides.[1] Roofs and bridges are the most common structures built with trusses. A single truss cannot resist lateral stresses and therefore, to be stable, a structure must be composed of two or more interconnected trusses. In bridges, the interconnecting members, consisting of laterals, floor beams and sway frames, allow the trusses to share in lateral, uneven or concentrated loading such as wind loading or lopsided vehicle loading.[2]

Wooden bridge trusses were constructed in the United States by Theodore Burr in 1804 and Ithiel Town in 1820, but these and other early truss bridge designs were not based on the scientific principles involved. Among the earliest bridge builders to apply mathematical engineering principals to the design of trusses was Thomas Pratt. Pratt was born in Boston in 1812, entered Rensselaer Polytechnic Institute at age 14, became an engineer with the United States Army Engineers at 18, and began a professional engineering career with Boston & Maine Railroad at age 21. Pratt worked the rest of his life in the employ of various New England railroad companies.[3]

Pratt is famous for a bridge truss design he patented in 1844, (US Patent No. 3523) consisting of two parallel chords connected by vertical wood posts in compression and double wrought iron diagonals in tension. Pratt's design was similar in appearance to an earlier truss patented by

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William Howe, but functioned structurally opposite. The Howe design put the verticals in tension and the diagonals in compression.

The Pratt truss is considered to be the first scientifically designed truss, incorporating what are now considered basic structural engineering principles. Pratt used shorter compression members, allowing members of smaller cross section to be used without sacrificing overall strength. This innovation provided a lighter truss requiring less material yet offered greater span and load bearing capability than the other truss designs of the time.[4] A contemporary of Pratt's, Squire Whipple, is credited with publishing the first method of mathematically computing the stresses in bridge frames with his 1847 publication of *A Work on Bridge Building*. This treatise, along with Herman Haupt's 1851 work *The General Theory of Bridge Construction*, are considered the seminal works on the analysis of framed structures.[5]

Pratt=s patent also diagramed and set forth claims to a truss design with a polygonal top chord. The polygonal version further reflected Pratt's understanding of the application of mathematical principles in calculating the forces involved and the precise strength of material required to counter those forces. The center panels, where the strains were the greatest required the tallest panels, with the posts getting successively shorter toward the ends of the bridge. The primary advantage of the design was a reduction in the weight of the bridge, or dead load, allowing for greater spans without increasing the sectional area of the bridge's structural members. A savings in material cost was a direct result, however, this advantage was largely offset by the cost of having to fabricate a greater variety of members.[6]

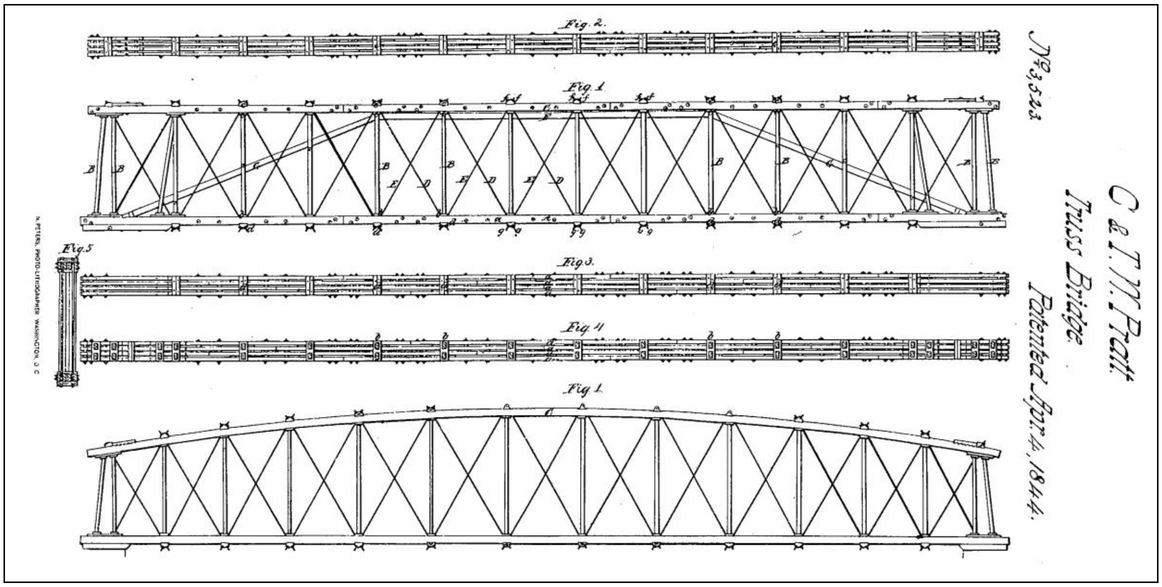

Figure No. 1: Truss diagram from 1844 US Patent No. 3523, issued to Caleb and T. W. Pratt

The polygonal variation of Pratt's truss became known as the Parker truss after Charles H. Parker added built-up wrought-iron compression members of his own design and built several bridges of the type for railroad use during the 1870s and 1880s.[7] [This report is on the parallel-chord design, universally referred to as the Pratt Truss.]

The use of Pratt's truss for the deck of John Roebling's Niagara River Suspension Bridge in 1855 drew worldwide attention to the design and undoubtedly contributed to its increased use. The truss was easily structurally analyzed by either the graphic or the mathematical methods that had been developed by 1850. Structural analysis permitted the stresses in each member to be calculated under various conditions of loading and led to the development of the polygonal form in which the height of the panels increased toward the center of the span where the stresses are highest. "By the 1870s, most bridge company designs were not Warren-Monzani forms but variations of the Pratt truss. Numerous top chord profiles and cross sections were used and the tensile diagonals generally intersected more than one panel. Following a period of experimentation and growth in the understanding of statically determinate truss forms, the Pratt form was simplified by eliminating counters and adjustable elements."[8]

The Pratt truss design proved especially well adapted to all-metal construction. By the 1860s the use of wood posts was replaced with cast iron columns and wrought iron columns such as the "Phoenix Column" invented by David Reeves of Phoenix Bridge Company. In 1871 the Pennsylvania Railroad modified the Pratt by subdividing the panels to achieve more efficiency and rigidity in longer spans and the subtype became known as the Baltimore truss.[9] As stated above, Charles Parker designed and built railroad bridges of the polygonal Pratt type during this time. His addition of wrought-iron top-chords and posts of built-up rolled members Aformed of an I-section beam either rolled or built-up of plates and angles@ would prove to be his greatest contribution.[10] The combination of Parker's built-up compression members with the simpler and cheaper parallel chord design was soon to become the bridge truss design of choice.

By 1889 the Pratt truss in its various metal forms ranked first in usage for railroad bridges.[11] The widespread adoption of Bessemer steel for bridge structural members in the 1890s and the movement from pin-connected to riveted spans led to the increased the use of the Pratt for high, long span bridges. As a whole, highway bridges lagged well behind railroad bridges in terms of technology for obvious reasons: railroad bridges carried immense loads and therefore required huge structural members and careful designing to guarantee safe, long-service structures. The brightest engineers and the latest developments in materials and methods were employed. Successful competition was dependant upon the quality of a railroad's rolling stock and the quality of the road (rails, bed, grades, curves and bridges) and when it came to bridges the best and heaviest that money could buy was usually wanted.

Highway bridges on the other hand, with the exception of large city bridges, were light structures, typically designed, manufactured and erected by smaller bridge building companies competing to provide the least expensive structure possible. Their capital-challenged customers – municipalities seeking simple but more efficient road systems to get their taxpayer's goods to market – were content to accept less-than-cutting-edge technologies. By the 1890s, the design of pin-connected trusses like those of the Stratford-Maidstone Bridge had become standardized and available “off the shelf” from the many bridge building firms.

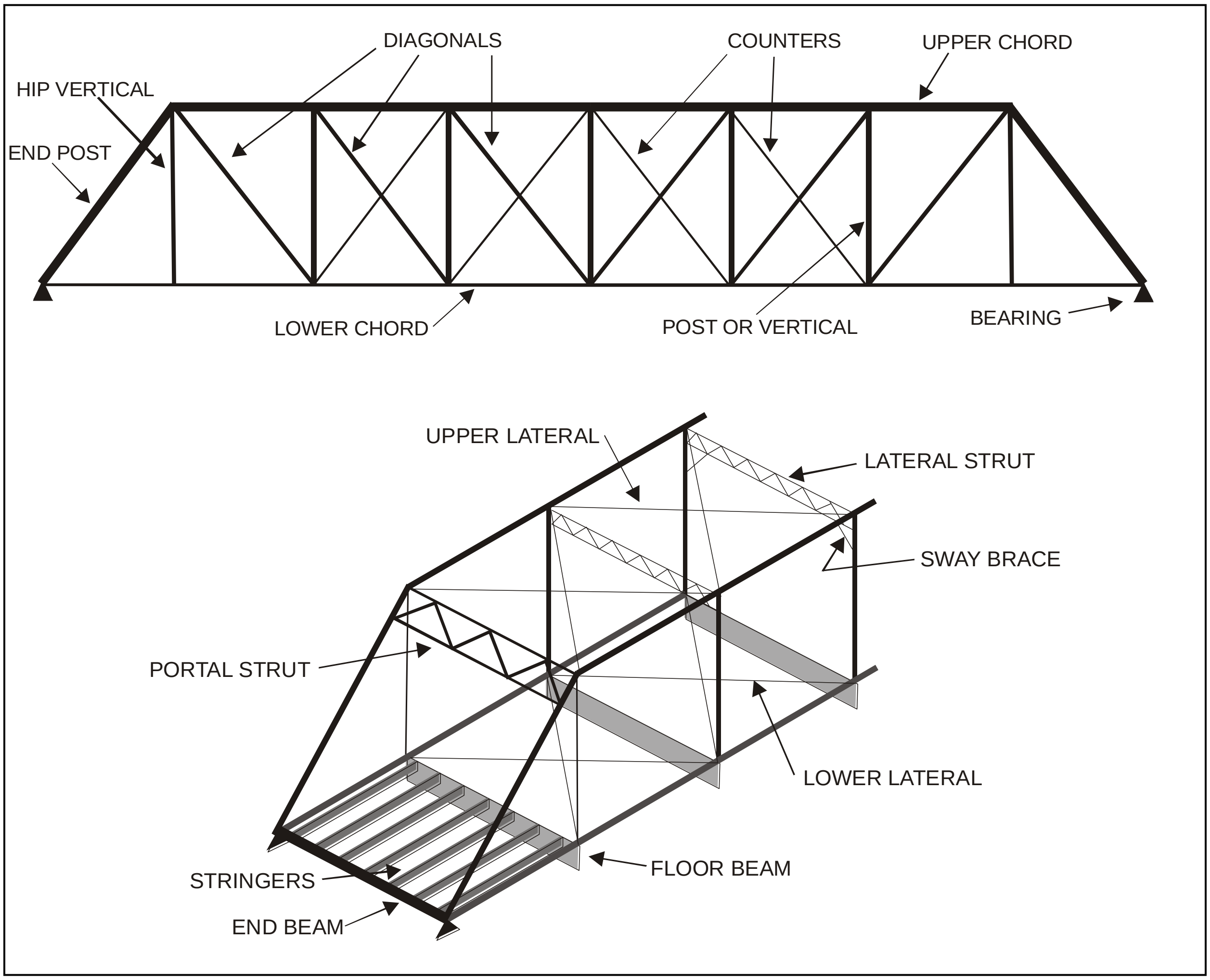

Figure No. 2: High Pratt Truss bridge terminology.

The transition from iron to steel for bridge building occurred rapidly over the course of the last two decades of the 19th century as the strength of the new material increased and the cost of production decreased. Structural shapes that had been produced in iron were made with steel instead allowing truss designs to remain essentially the same.

The transition to bridges with all-riveted connections was more complicated. The merits of rivet-connected joints over pinned-connections were hotly debated in the bridge engineering community from about 1880 into the early 20th century. In terms of their practical application, the railroads could deliver large riveted bridge sections by rail to the bridge site, unload and place them with derrick cars and then field rivet them together with air-powered rivet guns supplied by steam driven air compressors. These assets were largely unavailable to small rural highway bridge builders.

Wrought Iron to Steel

Pratt truss highway bridges from the late 19th century commonly utilized a combination of steel and wrought iron members. In New Hampshire these bridges are believed to include the Antrim-Bennington (193/100) Bridge built 1893, the Stratford-Maidstone (098/064) built in 1893, and the Shelburne (122/110) built in 1897.

C.K. Smoley states that

> In the earlier bridge trusses, wrought iron was used for the tension web members, and later on replaced timber and cast iron in all the members. As loads increased it was necessary to build bridges stronger; this could have been done using heavier members of wrought iron, but, on account of the high cost of such members, it became very desirable to replace the material with another having greater strength and not inferior in other properties. Steel was found to possess the needed requirements, and superseded wrought iron in nearly all forms of structural work.[12]

According to J.A.L. Waddell, "wrought iron remained the almost universal bridge metal until 1880; but between then and 1890 open-hearth steel came into vogue, supplanting entirely the wrought iron."[13] In 1892, F.H. Lewis presented a paper on soft steels in bridges before the Engineer's Club of Philadelphia that "did much to convince engineers that soft steel was as reliable as wrought iron."[14] By 1894, structural wrought-iron shapes "became commercially extinct, and those who had preferred wrought iron when it could be obtained, used soft steel."[15]

In 1885, Johann Bauschinger, the well-known materials expert and professor of mechanical engineering at the School of Technology of Munich, published the results of an extensive series of experiments comparing the welding qualities of wrought iron and various steels, showing that the properties of wrought iron allowed for stronger welds than were possible with steel. The chemical and physical properties of the soft and medium steels produced by the open hearth process and used for bridges in the late nineteenth and early twentieth centuries made proper welding impossible with the techniques known at the time. The higher carbon content and presence of manganese and other elements, in conjunction with the homogenous distribution of those elements to form a nearly uniform crystalline structure, resulted in brittle welded joints contaminated with oxides.[16] When the fabrication of bridge members required welding, wrought iron was used exclusively up to about the late 1920s, when improved methods of welding steel were developed.[17]

Although welding techniques adapted to steel had not been developed by 1893 when the Stratford-Maidstone and Antrim-Bennington pin-connected Pratt truss bridges were built in New Hampshire, specialized and powerful steam-powered forging machines were available to fabricate wrought-iron or steel eyebars without welding. The bars were heated, upset (thickened by hammering on the end), and pressed in dies to form an enlarged, flat, circular shape at the end that was then drilled, or punched and reamed, to fit the diameter of the pin to be used in the connection. This process created an eye with the same strength as the bar and eventually eliminated the loop-welded wrought-iron eyebar from common use. The development of hydraulically powered upsetting and die-forging machines increased eyebar production. A die-forged eyebar dating from after about 1890 is almost certainly of steel.[18] By 1898 only a few of the largest bridge fabricating shops possessed steel eyebar manufacturing equipment, and those that did not either purchased the steel eyebars from others or substituted wrought iron.[19]

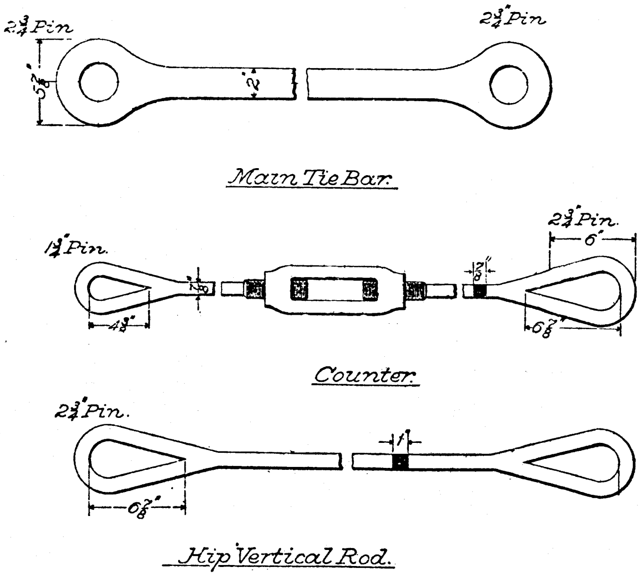

Figure No. 3: Wrought iron eyebars (top) and loop bars used in 19th century and early 20th century Pratt Truss bridges. (Colliery Engineering Company, 1897).

With the exception of loop-welded eyebars that were invariably wrought iron, it is hard to differentiate between wrought iron and steel bridge members produced in the late 19th century. Wrought-iron loop-welded eyebars (or loop-bars) were commonly used for truss diagonals and hip verticals into the 20th century. They can be easily identified by their elongated eye, indicating that a straight bar was bent back upon itself to form a loop and then joined by hammer welding. The process of making a welded joint in wrought iron is accomplished while the metal is intensely heated to a nearly molten state. The chemical properties of wrought iron allow the metal to be joined using special techniques in a way that prevents the formation of a weak joint.[20]

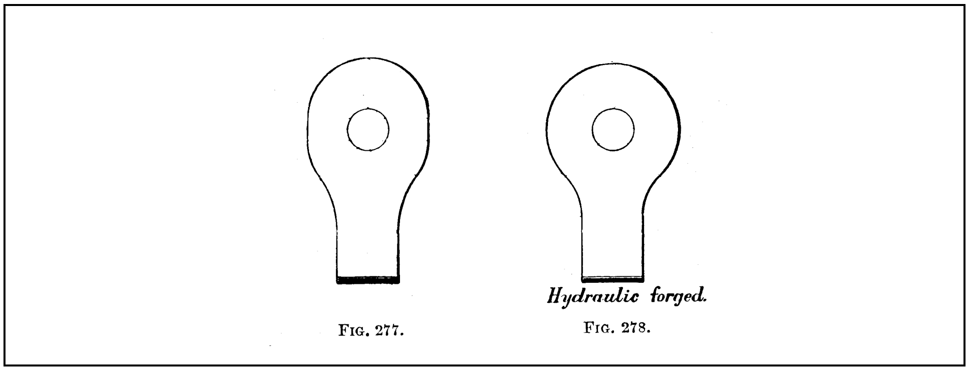

Figure No. 4: Eyebar heads and eyes, hammer forged on left, hydraulically die-forged on right, either of wrought iron or steel, but die-forged were typically steel after about 1890. (Warren 1894, p. 221).

Although steel had almost completely supplanted wrought iron for structural shapes by the mid-1890s, the use of wrought iron for the thin diagonal tension members of light highway trusses continued briefly into the early twentieth century for several reasons. The fibrous crystalline structure of wrought iron not only provided superior welding characteristics over steel, but made it stronger in tension, less brittle, and less subject to fatigue or stress fracture than early steels. Because truss diagonals are subjected to repeated shocks from vehicle impact loads, a potentially adverse effect that worsens over time in pin-connected trusses owing to wear and maladjusted counter-diagonals, wrought iron remained, for some engineers, the material of choice for such applications. The practice was mostly limited to early highway bridges of very light-capacity design, both in weight and traffic. Such bridges required diagonals with cross-sectional areas in some instances of less than 1 inch. Wrought iron is also considerably more resistant to corrosion than steel, an important factor in members of small sectional area. In contrast, the massive high-capacity steel-truss railroad bridges of the same period commonly have steel die-forged eye-bar diagonals with cross-sections of 10" square or greater. Progressive weakening as a result of corrosion or fatigue from overloading is less of a worry in large-section members. Wrought iron was therefore particularly well suited to the structural requirements of a light diagonal tension member, and although significantly more expensive than steel, the small quantities involved justified its use.[21]

By the second decade of the twentieth century, several trends led to the disappearance of the loop-welded wrought-iron eyebar. An increase in the use of motorcars and motor trucks and the need for highway systems to carry increased traffic created the need for larger, heavier bridges. Steel in tension, especially eyebars had been proven reliable through two decades of service, during which time steel manufacturers continually improved the quality of “run-of-the-mill” structural steel while reducing its cost.[22] Finally, all-riveted steel trusses came into widespread use for short-span bridges, leaving pin-connected trusses for long spans and for those circumstances when the site conditions dictated construction methods that favored the attributes of pin-connected assembly.

Pinned Connections to Riveted Connections

In the United States, it was not until the last two decades of the 19th century when trusses with riveted instead of pinned connections came into widespread use.[23] Riveted-joint construction was the preferred method in Europe during the 19th century but dismissed by American engineers as inefficient in terms of labor, material and ease of construction. Alfred P. Boller, a noted consulting bridge engineer from New York, gave the following assessment of pin-connected bridges in 1890:

> This American system, as it is universally called, permits the most economical use of material possible, is wonderfully well adapted for long spans, and enables the engineer to select the quality and shape of material best adapted for any given portion of his design. It is a system that permits of closer harmony between theory and practice than is possible to attain in the European method or its American imitation, concerning which enough has been said to show how lamentably deficient that system is in this particular. In a bridge on the American system, the strains, being axial, coincide with the skeleton diagram of the truss, and, further, the strains can be accurately computed, and need have no more material provided to meet their action than is absolutely necessary.[24]

The majority of American engineers agreed with Boller and pin-connected bridges remained the dominant form in the US, at least for long spans, well into the twentieth century. For shorter spans, however, all-riveted construction was already establishing its place in American bridge building. The greatest practical advantage of the riveted truss over the pin-connected truss was its rigidity and resistance to "lateral and vertical vibrations," a feature that the railroads were first to appreciate due to the high impact loads induced by heavy, fast moving locomotives.

The riveted highway bridge seems to have come into use in the US about 1880. James Owen, Engineer for Essex County New Jersey, reported to the American Society of Civil Engineers that he had "for the last few years, given preference to riveted trusses of low depth with angle iron bracing and triangular panels; a structure of this kind has few flat or round bars to vibrate, and is to a certain extent homogenous." [25] The triangular panels Owen refers to suggest his bridges were Warren rather than Pratt trusses. An early example of a riveted metal truss highway bridge found in the literature is the Western Avenue Bridge built in 1882 over the Illinois and Michigan Canal in Chicago, a through truss with a span of 118 feet.[26]

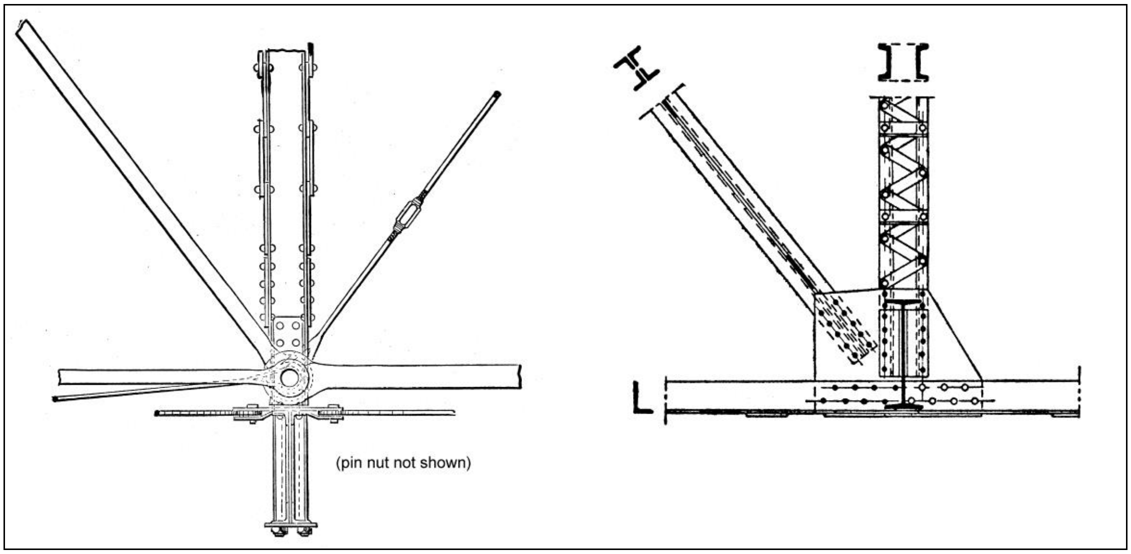

Figure No. 5: Example of Pratt truss lower chord and floor beam connections. Pinned example on left is of the type used on the three surviving 19th century NH bridges with the floorbeam suspended from the pin with U-bolts below the lower chord. The riveted example on right is typical of surviving 20th century NH bridges. It shows the floor beam framed into the lattice column above the lower chord and all members joined with rivets and angles to a gusset plate. (Colliery Engineering Company, 1897; Ketchum, 1920).

Owen (1882) was of the opinion that due to the "lateral and vertical vibrations" inherent in pin-connected trusses, "all highway bridges, up to 75 feet, or even 100 feet span should be riveted structures, as that form of construction seems best able to absorb or prevent this vibration."[27] Owen continues:

> There are pin-connected bridges in his [the author] jurisdiction that have carried a 20-ton steam roller (giving a load of over 300 pounds per square foot) with little deflection, which will quiver and vibrate to a great degree at the passage of a fast pony and carriage, the tension members in the trusses will so rattle that they have to be bound with wire, the nuts, unless the heads of pins are thoroughly upset, will work loose and have to be replaced, and the floor bracing will undulate. This condition of things seems to the writer very objectionable, and though no defined damage takes place, it is very probably that the molecular condition of the iron will more quickly be changed, and its strength deteriorated.

During the latter part of the 19th century, the majority of highway bridges were designed and built by local or regional bridge building companies who marketed them through traveling sales agents.[28] Competition for the limited funds that small towns and counties could muster for road and bridge building often resulted in bridge designs that were as light and economical as possible. New Hampshire's three surviving high Pratt truss bridges dating from the 1890s are examples from this period. There were no uniform highway bridge design standards at the time and it was only after the failure of several bridges that were determined too light for the intended loading that efforts to reform of the highway bridge building business were made.[29]

An early proponent of the reform movement was J.A.L. Waddell, a consulting engineer from Kansas City who called for laws requiring state inspection of all bridges, standard specifications, drawn plans for bridges made in accordance with the specifications, and competitive bidding based on the plans.[30] Waddell's recommendations were largely dismissed as unworkable, but soon after specifications for the design of highway bridges were published by A.P. Boller (1890), Waddell (1891) and others. More debate on the merits of pin versus riveted truss connections followed.[31]

Electric street car lines and heavy steam powered traction engines and road rollers that came into use at the end of the 19th century placed large and unanticipated loads on existing bridges resulting in the collapse of more than a few.[32] Riveted spans were used in greater numbers to replace older pinned trusses, especially by streetcar companies building new combined highway-streetcar bridges along primary urban and suburban roads. The advantages of the riveted bridge were noted as being particularly suited to pony trusses that lacked overhead bracing and therefore could not be adequately braced for lateral stiffness.[33]

By 1900 even long-span truss bridges with all-riveted connections were finding increasing acceptance with American engineers. Riveted connections provided a stiffer bridge and allowed for greater distribution of stresses at the joints and a subsequent savings in metal costs. The introduction of the portable air powered riveting gun in the early part of the century allowed for the field assembly of riveted connections, eliminating the expensive and high maintenance pin connected joints. By the 1920s riveted connections had replaced pin connections as the primary method of metal truss bridge construction in the U.S.

The early-to-mid twentieth century brought advances in steel truss design, precipitated by devastating floods in New England during the 1920s-1930s (see *Floods of 1927 and 1936* below). Title II of the National Industrial Recovery Act, required that “all plans must be submitted to and approved by the [federal] Bureau of Public Roads before construction can commence and all work [shall be] carried out under State and [federal] Government supervision.”[34] Pre-flood bridges all feature built-up members: various combinations of plates, channels and angles connected with rivets. Trusses constructed post 1927 used this technique for their top and bottom chords, but vertical and diagonal members between the chords were usually rolled I-beams that required no assembly. The obvious advantage of such members was to speed reconstruction by minimizing shop time. In 1929, for the first time the American Association of Highway Officials’ “Standard Specifications for Highway Bridges” recommended all rolled sections for truss webs.[35] Many of the high Pratt truss bridges constructed during this period feature standardized span lengths and shared engineering detail.

Good Roads Movement (1880-1910)

Virtually every bridge built in New Hampshire during the nineteenth century was built either by a town or by a private bridge company. The state had no highway department, and state government built roads and bridges only on rare occasions, under special legislation.[36] The White Mountain region received most of the little funding the state offered. A major early campaign to improve highways and bridges called the Good Roads Movement, began in the 1880s and continues today under the auspices of the National Good Roads Association. The purpose of the Good Roads movement in its early years, as today, was to ensure that American roads were adequate to get people and goods from place to place.

In New Hampshire much concern was expressed over the fact that local farms were in decline and could not be made successful unless farmers could get their produce to market-usually to a railroad depot. The early Good Roads movement took the form of a widespread campaign to convince towns to appoint knowledgeable road agents, to buy the machinery necessary to repair deteriorated gravel roads, and to replace bridges of insufficient load-bearing capacity with new ones, usually of steel, with the ability to bear much heavier loads.[37] This translated into the construction of better roads and bridges in New Hampshire to accommodate both farmers who needed to get their product to the nearest train depot and the tourism industry that advocated New Hampshire as a vacationer’s destination point at the turn of the twentieth century.

The rise of private bridge companies that sold standardized bridge designs during the late nineteenth and early twentieth centuries coincided with the Good Roads Movement. Towns could contract with any number of bridge firms that advertised their proven bridge designs throughout New Hampshire. From the mid-nineteenth century through the early twentieth century, intense competition pervaded the bridge industry. Rival sales agents touted the particular qualities of their firm's patented designs, such as less material and lower cost, greater strength, or even more handsome appearance.

Berlin Iron Bridge Company was one of the pre-eminent examples of a company that used a distinctive product as an aid in marketing. The dominant builder of metal truss bridges in New England in the last two decades of the nineteenth century, Berlin Iron Bridge Company evolved from the Corrugated Metal Company, a manufacturer of shutters, shingles, ceilings and roofs of rolled iron.[38] The company began to fabricate metal roof trusses during the mid-1870s and to build bridges about 1879. Acquiring the rights to William Douglas’ 1878 patent for lenticular bridge trusses, the company acknowledged its growing specialty by renaming itself the Berlin Iron Bridge Company in 1883. In 1889, the company claimed to have built over ninety percent of the iron highway bridges erected in New England and New York during the preceding decade. Other important bridge companies that constructed bridges throughout New Hampshire during this period include the Groton Bridge and Manufacturing Company and Boston Bridge Works.

Some of the few remaining pin-connected High Pratt truss bridges in New Hampshire were constructed during the late nineteenth century in response to the Good Roads Movement. These bridges include:

- Antrim-Bennington No. 193/100 Thompson's Crossing Bridge over Contoocook River;
- Stratford-Maidstone No. 098/064 over Connecticut River;
- Shelburne No. 122/110 Meadow Bridge over Androscoggin River.

Thompson's Crossing Bridge was built in 1893 by the Berlin Iron Bridge Company as a joint enterprise of the towns of Antrim and Bennington. The construction of this bridge helped facilitate better access to goods and services around these rural communities. The Stratford-Maidstone Bridge was constructed in 1893 by the Berlin Iron Bridge Company to improve communications with Vermont and to provide access for farmers to get their goods to the railroad depots in North Stratford, NH.[39] The Meadow Bridge was built in 1897 by Groton Bridge and Manufacturing Company as a joint-funded effort between the state legislature, the Town of Shelburne, and local citizens. The Meadow Bridge was constructed directly in response to the community's use as a summer tourist destination during the late nineteenth century.

Development of the New Hampshire Highway Department (1905-1945)

Frank West Rollins, a proponent of conservation and tourism in New Hampshire, became one of the state's leading advocates for good roads.[40] Writing in *The New England Magazine* in 1897, Rollins envisioned a state-built boulevard extending from the Massachusetts border through Franconia Notch and along the Saco River into Maine. In an age when the state's old network of taverns had diminished under the influence of the railroad, Rollins saw the need for roadside accommodations offering food, shelter, and maintenance. To realize this vision, Rollins recommended the creation of a state road commission like one already established in Massachusetts. He foresaw the state's employment of a chief highway engineer, with assistants in each county who would not only maintain state roads but also train local road agents.

The state legislature of 1903 passed "an act to provide for a more economical and practical expenditure of money appropriated by the state upon construction and repair of highways."[41] Under this act the governor appointed an engineer to take charge of all highway work, upon which state funds were expended. True to Rollins' vision of six years before, this act created the post of state highway engineer, called for a general highway survey of the entire state, designated certain roads as state highways, and prepared the way for a bill in the next legislative session that would detail the methods by which the state would construct roads in its own right and in partnership with towns.

Under this legislation, Governor Nahum Batchelder appointed three engineers, Arthur W. Dean of Nashua; William A. Grover of Dover and John W. Storrs of Concord; to supervise the expenditure of funds appropriated by the legislature. John W. Storrs, then employed as an engineer by the Boston and Maine Railroad, was designated highway engineer for Coos, Carroll, and Grafton Counties. Storrs immediately took up Rollins' vision of north-south boulevards leading from the Massachusetts border to the White Mountains. Between 1903 and 1905, Storrs worked to persuade an initially skeptical governor and council of the need for three roads to run north along the Connecticut, Merrimack, and Saco River valleys, converging near Mount Washington.[42] Arthur Dean's work during the same period precipitated the state legislature to appoint him as the first State Highway engineer under the State aid law which was adopted by the legislature in 1905.

The passage of New Hampshire's first state-aid highway law was secured in 1905 with the following provisions:

- an annual appropriation of $125,000 to be apportioned to towns seeking state aid;
- authorized towns to raise additional highway funds to be used as a match for state highway monies;
- appropriated state funds to maintain designated state highways and declared certain roads to be state highways;
- created the post of state highway engineer;
- provided the consulting services of the state highway engineer and his staff to any town.[43]

Many of the first roads constructed from these state monies did not fit into a general state wide system therefore the legislature amended the original state law in 1909 by designating the three north and south routes through the state as trunk line highways and towns and cities located along these routes were required to expend their state appropriations through state aid law.

A marked change in the administration of state aid highways was made by the legislature of 1915 that abolished the office of state engineer and created a state highway department, with a highway commissioner who was appointed for a five-year term by governor and council.[44] The 1915 state law also made towns liable for damages when bridges failed under loads of six tons or less. This law had the effect of motivating towns to replace weakened bridges with structures having a design loading above six tons.

One of the most prolific bridge designers in New Hampshire during the early twentieth century was John Storrs. Storrs was born in Montpelier, VT but his family moved to Concord, New Hampshire in the early 1870s. Storrs started his long career in structural engineering in the 1890s, as a bridge engineer for the Boston and Maine Railroad. As noted above, in 1903 he began simultaneously to serve as the state engineer for Carroll, Coos, and Grafton counties, New Hampshire. Storrs left state employment in 1905 to establish his own engineering firm in Concord, soon taking his son Edward as his partner.

To assist towns in improving the bridges for which they were responsible, Storrs published a non-technical book on bridge design in 1918. Entitled, "*Storrs: A Handbook for the Use of Those Interested in the Construction of Short Span Bridges*, the 75-page volume was intended to be of assistance to local road agents, clerks and selectman who would be involved in the construction of small bridges and culverts.[45]

Storrs' private engineering practice emphasized steel truss bridges of widely varying designs. His bridges spanned the Connecticut River at Claremont and Woodsville; the Merrimack at Concord, Boscawen and Hooksett; the Androscoggin at Berlin; the Pemigewasset at Hill and Sanbornton; and many other streams throughout New Hampshire and neighboring states. Most of Storrs' longer trusses were riveted Pratt or Parker trusses, highly popular designs of the time.

Bridges designed by Storrs within this context include:

- 152' single-span High Pratt truss in Milford in 1910;
- 423' three-span with two High Pratt and one Low Warren truss spans in Berlin in 1915;
- 660' two-span High Pratt truss in Concord in 1915;
- 118' single-span High Pratt truss in Henniker in 1915.

Storrs foresaw the need to build bridges with greater load capacity when he noted that most of the earlier steel bridges constructed by New Hampshire towns in the nineteenth century were of too light construction to safely handle the loads that were passing over the highways by the early twentieth century. The Storrs' bridges referenced above were designed with a capacity for loads equal to twelve-ton trucks and steam road rollers and were likely constructed in response to the 1915 legislative act that made towns liable for damages when bridges failed under loads of six tons or less. Concurrent with New Hampshire's early highway growth, the federal government advanced the organization of its federal transportation department between 1893 and 1915. Secretary of Agriculture J. Sterling Morton instituted the Office of Road Inquiry on October 3, 1893.[46] In 1905, an act of Congress consolidated the renamed Office of Public Roads Inquiries with the Division of Tests of the Bureau of Chemistry into the Office of Public Roads (OPR). Soon after, the OPR established a Division of Bridge and Culvert Engineering to collect data, publish circulars, and construct demonstration bridges. Within a few years, the division was publishing standard bridge specifications and preparing standard plans for a variety of structural types for state and local use.

The Federal-Aid Road Act of 1916 ushered in a new level of commitment by the federal government to road building, including the building of bridges, by acknowledging the need for a more efficient road network that connected the states. The Act was in response to the advocates of the Good Roads Movement and to lobbying from groups and organizations such as farmers, the interstate road associations, and the United States Postal Service, which had problems delivering mail in many rural areas due to the poor condition of the roads. By the 1920s, newly funded state DOT's controlled large amounts of federal construction monies, which were tied to federal restrictions, such as the use of approved standardized bridge designs.

As it entered the era of modern highways and increased automobile traffic, the New Hampshire Highway Department began to employ excellent designers, placing them under the supervision of bridge engineer John W. Childs. During this period, the New Hampshire Highway Department was distinguished by employees of national reputation including Harold Langley, Henry B. Pratt, Jr. and Robert J. Prowse.[47] Writing in *New Hampshire Highways* in 1929, Bridge Engineer Childs noted that the increase in modern traffic had reached the point in New Hampshire where it was affecting the efficiency of the highway bridges and culverts to a serious degree. The replacement of inadequate bridges was costly, often too much of a financial burden for New Hampshire towns to bear. Recognizing these conditions, the state legislature authorized the Highway Commissioner to set aside annually from the general funds of the Department the sum of $150,000 for the construction of bridges on the trunk line system and $50,000 for the construction of bridges on state aided roads not included in the trunk line system. One such example of a High Pratt truss bridge constructed in response to this legislation is Plymouth 141/143 constructed in 1930 along Route 3 over the Baker River. Historic plans and records specify funding for this bridge as “T.L.B” or “Trunk Line Bridge.”

During the 1930s, the New Hampshire Highway Department was active in the construction of a number of highway bridges using both federal and state monies. In 1934, Congress passed the Hayden Cartwright Act that for the first time allowed the use of federal dollars for highway improvements in municipalities. Other federal funding during this period came under the auspices of the Works Progress Administration (WPA). The WPA was a relief measure established in 1935 by executive order. Between 1935 and 1943, the WPA built or maintained over 570,000 miles of rural roads, erected 78,000 new bridges and viaducts, and improved an additional 46,000 bridges throughout the United States. Some of the Pratt trusses constructed during the late 1930s under the supervision of the New Hampshire Highway Department note “W.P.F.R., and W.P.G.H.” indicating that monies came in part from Works Progress funding. 1945 marks the end of the period in which the New Hampshire Highway Department constructed High Pratt trusses. While the High Pratt truss was erected in large numbers during the last quarter of the nineteenth century and into the first decades of the twentieth century, it later was superseded in popularity by the Warren truss and other bridge types such as concrete slabs, concrete T-beams, I-beams, and plate girders.

Floods of 1927 and 1936 (1927-1937)

Many of the High Pratt truss bridges during the late 1920s through 1930s were constructed in response to two large natural disasters. The floods of November 3 and 4, 1927, exceeded all previous flood records in northwestern New Hampshire. The flood was the result of two violent storms that converged on New England, one from the south and one from the west. The Connecticut River rose thirty feet at Hanover, New Hampshire. Damage to roads and bridges in New Hampshire was estimated at $2.5 million. Damage in Vermont, where the eastern slopes of the Green Mountains received especially heavy rainfall, was far greater than in New Hampshire.

New Hampshire suffered again from widespread flooding in March of 1936. Damage from this series of floods was greater in New Hampshire than the destruction of 1927. The region was emerging from one of the severest winters on record when hard rains began falling from the Ohio Valley to Maine around the 15th of March. The hillsides were laden with snow, rivers were packed with ice and the underlying earth was still frozen solid. By the 19th, a massive low-pressure center, formed in Texas and heavy with moisture from the Gulf of Mexico, pushed into the region dumping torrents of rain on the sodden snow pack and already flooded rivers.[48]

The storms' toll on New England was severe: 24 dead, and an estimated 77,000 homeless and $277 million in damages. Albany and Binghamton, New York, Wilkes-Barre, Harrisburg, Pittsburgh and Johnstown, Pennsylvania, and cities and towns along the Ohio River also suffered extensive flood damage. The damage to bridges in New England was staggering with many of the new bridges constructed in response to the 1927 flood washed away or severely damaged by the impact of ice or by the pressure of water against lumber, buildings, or trees lodged against their sides. Over 700 bridges were replaced or repaired as a direct result of the floods.

By the time of the floods of 1936, the United States was in the middle of the Great Depression. The federal government had instituted several programs both to provide employment and to improve the nation's highways including the New Deal Act of 1933 that provided $400 million for road projects without a requirement for financial match. Funds appropriated under this law could be used on "secondary and feeder roads," thereby improving many rural highways. Much of the work after the 1936 flood was financed by the Works Progress Administration (WPA) and bridge plans accordingly bear the stamp "WPFR" meaning Works Progress Flood Replacement.[49]

New Hampshire was especially hard hit and lost the greatest number of bridges although monetary losses were greater in Maine and Massachusetts due to destruction of several large and recently constructed bridges. To expedite bridge repair and replacement, New Hampshire moved quickly and authorized a bond issue of $2 million to supplement the federal funds. These funds allowed the New Hampshire Highway Department to immediately initiate contracts with qualified bridge contractors while neighboring states were waiting for federal money. With the bond issue monies, New Hampshire was able to build fourteen temporary bridges and repair or replace 101 other bridges in addition to the 189 federally funded bridges built throughout the state.

In response to the disastrous floods of 1927 and 1936 occurring so close together, New Hampshire Senator Henry W. Keyes requested flood control assistance from the federal government. The result of Keyes' plea, together with the urging of many others, was passage of the federal Flood control Act of 1936 (Public Law No. 738, 74th Congress). Under this act, New Hampshire and other states were required: "to provide, without cost to the federal government, all lands, easements, and rights-of-way; to hold and save the United States free from damages due to the construction works; to maintain and operate the works after completion; and to provide tax reimbursement to affected towns."[50]

Many of the short-span bridges washed out by the floods of 1927 and 1936 were replaced by concrete bridges, concrete culverts and steel plate girder spans measuring up to a hundred feet in length. Longer crossings were spanned by steel truss bridges of various designs.

Among the Pratt truss bridges constructed between the Flood of 1927 and World War II were the following:

- 120’ High Pratt truss (Apthorp Bridge) over Ammonoosuc River in Littleton;
- 136’ High Pratt truss at Bridge Street in Littleton (no longer extant);
- 153’ High Pratt truss at Twin Mountain in Carroll (no longer extant);
- 136’ High Pratt truss (Pierce Bridge) at Bethlehem (bypassed);
- 136’ High Pratt truss at Gorham (no longer extant);
- 120’ High Pratt truss at Jefferson (no longer extant);
- 139’ High Pratt truss at Lead Mine in Shelburne (no longer extant);
- 168’ High Pratt truss at Plymouth;
- 168’ High Pratt truss at Bartlett (no longer extant);
- 136’ High Pratt truss at Effingham-Freedom;
- 168’ High Pratt truss at Goffstown (no longer extant);
- 168’ High Pratt truss at Greenville;
- 130’ High Pratt truss at Bartlett (no longer extant);
- 168’ High Pratt truss at Northumberland (no longer extant);
- 158’ High Pratt truss at Canaan (no longer extant);
- 136’ High Pratt truss at Errol (no longer extant).

Many of these spans shared the same span lengths and were built using standardized plans to avoid needless custom designing of bridges under emergency conditions. Most of the new spans incorporated standard specifications issued by the federal Bureau of Public Roads. The through truss bridges built in New Hampshire after the floods of 1927 and 1936 differed from older spans primarily in employing an increased number of rolled steel sections in their construction, with fewer built-up members. Table No. E-1 shows the extant High Pratt truss bridges within this context.

The concentration of High Pratt Truss bridges built in New Hampshire as a result of the floods provides an important record of the incremental changes that occurred in the design of the bridge type during the 1920s and 1930s. Riveted built-up bridge members essentially became obsolete during this period and were replaced after World War II by welded built-up members. The five remaining bridges of the original sixteen built during this period, embody both the design changes made on a national level by the standards developed by Bureau of Public Roads and the adaption of those standards by NHHD engineers to the requirements of a particular bridge design.

Table No. E-1: Summary of Extant High Pratt Truss Bridges in New Hampshire

Town	Bridge No.	Year	Carrying Over	Spans	Max Span	Historical Associations	NHDHR Inventory #
Antrim-Bennington	193/100	1893	Bypassed bridge over Contoocook River	1	96’	Good Roads Movement	ANT0003
Stratford-Maidstone	098/064	1893	Bog Road over Connecticut River	1	150’	Good Roads Movement	STR0015
Shelburne	122/110	1897	Bypassed over Androscoggin River	5	504’	Good Roads Movement	SHE0002
Hooksett	083/150	1909	Bypassed bridge over Merrimack River	3	490’	Storrs	HOK0019
Milford	062/138	1910	Bypassed bridge over Souhegan River	1	152’	Storrs	MIL0105
Berlin	252/077	1915	Pedestrian bridge over Androscoggin River	3	423’	Storrs	BER0040
Concord	070/117	1915	Sewall's Falls Road over Merrimack River	10	660’	Storrs	CON0278
Henniker	097/101	1915	Patterson Hill Road over Contoocook River	1	118’	Storrs	HEN0006
Bethlehem	127/178	1928	Bypassed bridge over Ammonoosuc River	1	136’	NHHD/1927 Flood	BET0016
Littleton	232/050	1928	Reddington Street over Ammonoosuc River	1	120’	NHHD/1927 Flood	LTL0022
Plymouth	141/143	1930	US Route 3 over Baker River	1	168’	NHHD	PLY0004
Henniker	095/100	1933	Western Avenue over Contoocook River	2	305’	NHHD	HEN0007
Effingham-Freedom	176/185	1936	Town Road over Ossipee River	1	136’	NHHD/1936 Flood	EFF0008
Lebanon	058/127	1936	US Route 4 over Connecticut River	3	390’	NHHD/1936 Flood	LEB0324
Greenville	075/114	1938	Power Dam Bridge over Souhegan River	1	168’	NHHD/1936 Flood	GRV0008

* NHHD – New Hampshire Highway Department

Section E Notes:

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[1] Clifford N. Ricker, *Construction of Trussed Roofs* (New York: Wm. T. Comstock, Publisher 1897), p. 37.

[2] F. C. Kunz, *Design of Steel Bridges* (New York: McGraw-Hill Book Company 1915), p. 189.

[3] American Society of Civil Engineers (ASCE), "Memoir of Thomas Willis Pratt." *Proceedings of the American Society of Civil Engineers* 1 (1876): 332-335; Carl W. Condit, A*merican Building Art, The Nineteenth Century*. (New York: Oxford University Press, 1960), p. 108.

[4] Condit 1960, p. 109.

[5] Henry Gratten Tyrrell, *Bridge Engineering. A Brief History...* (Evanston, Illinois: Pub. by author, 1911), p. 166.

[6] Thomas W. Pratt and Caleb Pratt, *Truss-Frame of Bridges, Specifications of Letters Patent No. 3,523, dated April 4, 1844.* (Washington, D.C.: U.S. Patent Office); Condit 1960, p. 110.

[7] According to bridge engineers Mansfield Merriman and Henry S. Jacoby, who assigned the name Parker Truss to the polygonal Pratt in their *Text-Book on Roofs and Bridges*, the type became "widely built for both highway and railroad service" after 1890. Merriman and Jacoby, Vol. 1, p. 212.

[8] Dario Gasparini and David Simmons. "American Truss Bridge Connections in the 119th Century. II: 1850-1900." *Journal of Performance of Constructed Facilities* (August 1997):130.

[9] J.A.L. Waddell, *Bridge Engineering* (New York: John Wiley and Sons 1916), p. 24.

[10] Parker did not claim priority for the idea of a curved top chord but developed an adjustable endpost that allowed simple variation of the overall length of the bridge in small increments. This made the bridge easily adaptable and suited as a replacement structure that could be dropped onto existing abutments without altering the structural characteristics of all the other truss panels. Parker=s second claim and his greatest contribution to bridge design was for a wrought-iron compression member, for the top chord or post. Charles H. Parker, Improved Bridge. Letters Patent No. 100,185, dated February 22, 1870. See also: Dennis M. Zembala, "Elm Street Bridge, over Ottauquechee River, Woodstock, Vermont." HAER No VT-3, 1983.

[11] Theodore M. Cooper, "American Railroad Bridges." *Transactions of the American Society of Civil Engineers* 21 (July 1889):11.

[12] C.K. Smoley, "*Bridge Details and Specifications,"* International Textbook Company, (Scranton 1927), pp. 3-4.

[13] Waddell, 1916, p. 17.

[14] Charles Lee Crandall, "A Review of the Development of Metal Bridge Building in America," *Proceedings of the Eighth Annual Convention of the American Railway Engineering and Maintenance of Way Association*. 11 (Chicago: Pub. by the Association, 1910), p. 145; F.H. Lewis, "Soft Steel in Bridges," *Engineering News* (March 26, 1892):309.

[15] American Railway Engineering and Maintenance of Way Association, "Historical Sketch of the Development of American Bridge Specifications," *Proceedings of the Sixth Annual Convention of the American Railway Engineering and Maintenance of Way Association, Vol. 6* (Chicago: Pub. by the Association, 1905):216.

[16] George Bartol, "Recent Developments in Iron and Steel Manufacture," *Journal of the Association of Engineering Societies* 9 (January 1890):14; John W. Langley, "On Some Physical Properties of Steel as Related to Its Composition and Structure," *Journal of the Association of Engineering Societies* 11 (April 1893):189-190.

[17] J.B. Johnson, *The Materials of Construction* (New York: John Wiley & Sons), pp. 129-131; Smoley, 1927, p. 4.

[18] B. L. Marsteller, "Inspection of Iron bridges and Viaducts," *Journal of the Association of Engineering Societies* 8 (January 1889):12.

[19] "American Bridge Shop Practice." *Engineering News* (April 21, 1898):257-258.

[20] Carl Gaylor, "Wrought Iron and Steel Eyebars," *Journal of the Association of Engineering Societies* 8 (April 1889):184.

[21] Gaylor, 1889, pp. 184-185; N.B. Wood, "Crystallization and Its Effects Upon Iron," *Journal of the Association of Engineering Societies* 1 (October 1882):284-285.

[22] Theodore M. Cooper, "New Facts about Eyebars," *American Society of Civil Engineers Transactions* 56 (1906):411-450.

[23] David Guise, "The Evolution of the Warren, or Triangular, Truss." *Industrial Archeology* 32 (No. 2, 1997):26.

[24] Alfred P. Boller, *Practical Treatise on the Construction of Iron Highway Bridges for the use of Town Committees.* New York: John Wiley & Sons, 1890, pp. 47-48.

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[25] James Owen, "Highway Bridges." *Transactions of the American Society of Civil Engineers* 11 (August 1882):286.
[26] "Riveted Warren Girder Bridge – Chicago." *The American Engineer* 4 (December 15, 1882):272.
[27] Owen, 1882, p. 286.
[28] Carl Gaylor, Highway Bridges. *Journal of the Association of Engineering Societies,* 16 (June 1896):264.
[29] Gaylor, 1896, p. 262. Gaylor states that movement was led by the Engineer's Clubs of Chicago, Kansas City and St. Louis.
[30] "Highway Bridges." *The Engineering Record* 38 (October 15, 1898):419. See *Engineering Record,* November 17, 1888 for the discussion.
[31] "New Highway and Railway Bridge Specifications." *The Engineering Record* 27 (March 25, 1893):331; Edwin Thacher. "Specifications for Highway Bridges." *Engineering Record* 27 (March 11, pp. 294-295; March 18, p. 315; March 25, p. 338, 1893).
[32] Albert W. Buel. "Highway Bridge Building." *Engineering Record,* 39 (December 24, 1898):76; "Fatal Collapse of a Highway Bridge." *Engineering Record,* 38 (July 23, 1898):160-161.
[33] Gaylor, 1896, p. 287.
[34] James L. Garvin, "New Hampshire's Highway Bridges: Masonry and Metal." Unedited draft, 1999.
[35] Matt Roth and Bruce Clouette. "Vermont Historic Bridge Survey: Final Report and Preservation Plan," Part II, "History of Bridge Building in Vermont, 1985:II-23.
[36] Garvin, 1999, n.p.
[37] Garvin, 1999, n.p.
[38] Richard M. Casella. *New Hampshire Historic Bridge Documentation for the Meadow Bridge*, Prepared for the New Hampshire Department of Transportation, Concord, NH, 2003.
[39] Richard M. Casella. *New Hampshire Historic Property Documentation, Stratford-Maidstone Bridge 098/064.* Prepared for New Hampshire Department of Transportation, Concord, NH, 2003.
[40] Garvin, 1999, n.p.
[41] F.A. Gardner. "New Hampshire's Highway System." *New Hampshire Highways Magazine,* 4 (November-December 1926).
[42] Garvin 1999:n.p.
[43] *Ibid*.
[44] *Ibid.*
[45] *Ibid.*
[46] *Ibid.*
[47] *Ibid.*
[48] Richard M. Casella. *New Hampshire Historic Property Documentation, Bartlett Bridge No. 191/139.* Prepared for New Hampshire Department of Transportation, Concord, NH, 2007.
[49] *Ibid.*
[50] *Ibid.*

F. ASSOCIATED PROPERTY TYPES

Description:

The typical Pratt truss design is characterized by vertical truss members, or posts, that define the panels of the trusses and act in compression. Extending diagonally across each panel is a tie, or tension member, which connects the upper chord of the truss to the lower, inclining toward the center of the truss. The Pratt truss is distinguished by parallel chords with vertical members acting in compression and diagonal members acting in tension. The typical span length of those High Pratt trusses found within this category are between 95' and 170'.

The upper chord and inclined end posts of a High Pratt truss typically consist of a riveted box-section member, built up with rolled channels on each side joined with a continuous top plate and lattice bars of stay plates on the underside. The lower chord is usually made up of paired angles connected with a continuous top plate or stay plates, or two channels with top and bottom stay plates. Posts or verticals are either built-up members on the pin-connected bridges, or single rolled members on the later riveted bridges. Diagonals may be rods, bars, paired angles or single rolled members. Upper and lower lateral ties consist of rods, bars or angles. Portal and intermediate lateral struts and sway braces may be built-up lattice bar and angle members or triangular trusses built with larger angles. The floor system consists of I-section floor beams and stringers with a wooden deck (wood decks have been replaced in most instances with concrete slab or open metal grid flooring).

The earlier type of connection used for truss bridge design was the use of pin-connected trusses. Connected with steel pins rather than riveted gusset plates, pin-connected bridges were common in the late 1800s and early 1900s. By the 1890s, the design of pin-connected trusses had become standardized and available “off the shelf” from the many bridge building firms that fabricated and erected thousands of essentially identical pin-connected truss bridges across America. The 1890s also ushered in the use of all steel components rather than the use of wrought iron in Pratt truss design.

By the early twentieth century, pin-connected truss bridges were giving way to bridges with all-riveted connections. Riveted connections provided a stiffer bridge, allowed for greater distribution of stresses at the joints, and created a subsequent savings in metal costs. By the 1920s, riveted connections had replaced pin connections as the primary method of constructing short- and medium-span steel-truss bridges.

The introduction of the wide flange or WF beam in the first decade of the 20th century by the Bethlehem Steel Corporation eventually led to changes in the design of truss bridges. Known as the "H” beam, Grey-beam, Bethlehem beam and finally the wide-flange beam, the shape was lighter, stronger and cheaper than fabricated (built-up) sections of the time. As the name suggests, the essential difference from the I-beam was that the flanges could be rolled much wider, equal to or even greater than the depth. The flanges could also be rolled thicker, 2 inches or more and most importantly, with a constant thickness that eliminated the interior flange slope of the I-beam. With all the flange faces parallel, WF beams can be more easily joined together into frames of columns and beams and quickly revolutionized structural steel design and construction. During the 1920s, US Steel Corporation and Carnegie Steel Company also began producing wide-flange shapes.

During the 1930s the rolled WF beam was increasingly used for the vertical posts in truss bridges instead of the built-up lattice columns that were labor-intensive to manufacture and more costly to paint and maintain. By the 1940s and 1950s, bridges were constructed in standardized sizes with similar engineering elements, including an increased number of rolled steel sections in their construction, with fewer built-up members. Long span deck plate girder bridges replaced the high Pratt Truss for highway spans up and exceeding 200 feet, and the more efficient Parker Truss design with its polygonal top chord took the place of the Pratt for longer spans.

Significance:

The Pratt truss was designed and patented in 1844 by Thomas W. and Caleb Pratt as a combination wood and iron bridge. Its application increased dramatically when cast and wrought iron began to be used in the 1870s and 1880s to replace the wood members. The Pratt truss was well-suited to all-metal construction. The introduction of Bessemer steel in the United States in the 1890s strengthened the favored status of the Pratt truss, which proved adaptable both to pin-connected and riveted spans for both railroad and highway work. By the 1890s, steel had replaced wrought iron as a bridge material, and the Pratt truss quickly achieved dominance in bridge design. In the early years of the twentieth century, steel High Pratt truss bridges outnumbered every other truss design used in the United States, and may have outnumbered all other truss designs combined. Today, because of continual replacement, pre-1900 Pratt highway trusses have become rare and early twentieth century Pratt highway trusses in New Hampshire are being bypassed or replaced at a rapid pace.

The bridges included in this type are found throughout the State of New Hampshire. They are historically significant under National Register Criterion A for contribution to the broad patterns of our transportation history, and architecturally significant under National Register Criterion C for embodying the types, forms, and methods of engineering and construction as associated with bridge building in New Hampshire in the nineteenth and twentieth centuries as well for their association with significant engineers and/or bridge building companies.

Bridges may have been associated with the Good Roads Movement, a major early campaign to improve highways and bridges during the late nineteenth and early twentieth centuries. The purpose of the Good Roads movement in its early years, as today, was to ensure that American roads were adequate to get people and goods from place to place. The rise of private bridge companies that sold standardized bridge designs during the late nineteenth and early twentieth centuries coincided with the Good Roads Movement. Bridges constructed during the late nineteenth and early twentieth centuries and associated with these phenomena have potential eligibility for listing in the National Register under Criterion A.

The development of the New Hampshire Highway Department during the early years of the twentieth century is another important theme of High Pratt bridge construction in New Hampshire. The New Hampshire Highway Department was established in the early twentieth century when the state legislature passed two laws that radically changed the role of state government in New Hampshire highway development. These laws created the post of state highway engineer, called for a general highway survey of the entire state, designated certain roads as state highways, and prepared the way for a bill in the next legislative session that would detail the methods by which the state would construct roads in its own right and in partnership with towns. A state law of 1915 made towns liable for damages when bridges failed under loads of six tons or less which had the effect of motivating towns to replace weakened bridges with new structures. Bridges constructed during the early twentieth century with documented ties to these early legislative initiatives have potential eligibility for listing in the National Register under Criterion A.

Bridges constructed in response to either the 1927 or 1936 flood may have historical significance. New Hampshire suffered from widespread flooding in November 1927 and again in March of 1936. Significant damage to highways and bridges occurred. In response to the disastrous floods occurring so close together, flood control assistance from the federal government was enacted on many subsequent bridge projects because so many crossings were breached. Many of these spans shared the same span lengths and were built using standardized plans to avoid needless custom designing of bridges under emergency conditions. Most of the new spans incorporated standard specifications issued by the federal Bureau of Public Roads. For their association with federal disaster funding in relationship to the floods of 1927 and 1936, bridges could have potential eligibility for listing in the National Register under Criterion A.

Bridges may have potential significance under Criterion C for their architectural/engineering importance. Principal types under study include pin-connected High Pratt trusses and riveted High Pratt trusses. The earlier type of connection used for truss bridge design was the use of pin-connected trusses. Connected with steel pins rather than riveted gusset plates, pin-connected bridges were common in the late 1800s and early 1900s, but only a few remain in New Hampshire today. A few of these earlier pin-connected bridges may have incorporated both wrought iron and steel components. By the early twentieth century, pin-connected truss bridges were giving way to bridges with all-riveted connections that provided a stiffer bridge. These riveted bridges were likely constructed solely of steel. Bridges constructed using pinned connections may have significance under Criterion C for their contribution to the development of structural engineering. Early examples of riveted bridges may have significance under Criterion C as examples of changing technology in bridge design.

Bridges may be significant under Criterion C for their association with an important bridge company, designer, or engineer. Important designers known to have worked on metal truss bridges include but are not limited to: Berlin Iron Bridge Company; Groton Bridge and Manufacturing Company; John W. Storrs (Storrs and Storrs); American Bridge Company; and New Hampshire Highway Department staff including Harold Langley, Henry B. Pratt, Jr., Robert J. Prowse and others.

Registration Requirements:

The period of significance for High Pratt Truss bridges in New Hampshire is 1890 through 1945 and includes the entire study period investigated as part of this context. Historic and cultural character defining features include those directly linked to important historical events that shaped the transportation of which they are a part. Physical character defining features of the High Pratt truss bridge type include the truss form, method of connection, top and bottom chords, vertical and diagonal members, lateral top bracing and features of the portal (i.e. struts, bracing). Bridges that are eligible only under Criterion A should retain their integrity of location and setting and enough materials and design to convey their historic feeling and association as High Pratt Truss bridges. High Pratt truss bridges eligible under Criterion C for engineering significance need not be in their original setting or location given the standardization of the design, but should retain integrity of design, materials, workmanship, feeling and association. Bridges should be intact, with an identifiable truss system, the majority of which should be original members or members replaced in-kind. The truss system should be capable of functioning, with or without structural reinforcement, but need not be in use for carrying traffic. Additions such as sidewalks, guide rails, replaced flooring and decking, and new abutments are acceptable as long as the truss system is in place. Specific considerations for eligibility under Criterion A and C are further defined below:

Specific considerations under Criterion A:

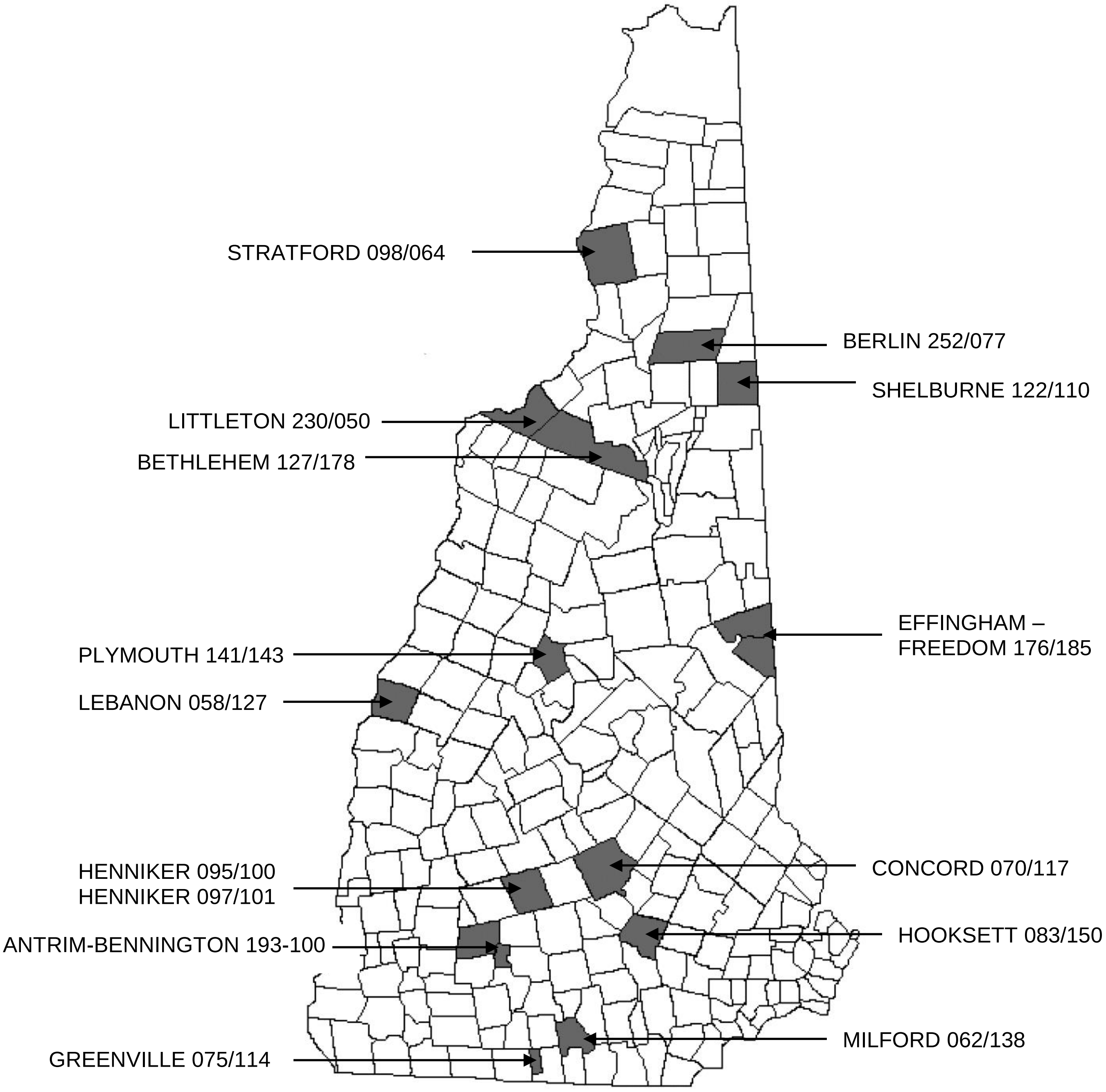
1. A bridge constructed in response to the Good Roads Movement to facilitate regional economic growth in the late nineteenth and early twentieth centuries.
2. A bridge constructed during the early years of the New Hampshire Highway Department in response to statewide and/or federal initiatives.
3. A bridge documented to be constructed in response to either the 1927 or 1936 floods using state and/or federal flood relief funds.

Specific considerations under Criterion C:

1. A well-preserved example of its type.
2. A rare survivor of a once common type.
3. An example of a work by an important engineer, architect, or firm.
4. Innovative, specialized or patented designs of recognized importance.
5. Architecturally exceptional bridges of recognized aesthetic importance (expressed through its prominence on the landscape or through the use of architectural features associated with portal design, railings or other decorative features that would make a particular bridge unique).

G. GEOGRAPHICAL DATA

The geographic area encompasses the entire state of New Hampshire.
Map below shows location of extant High Pratt Truss bridges in New Hampshire.



H. SUMMARY OF IDENTIFICATION AND EVALUATION METHODS

Several surveys and studies contributed to the preparation of this Multiple Property Documentation Form. These include the 1982 New Hampshire Historic Bridge Inventory prepared by Sverdrup & Parcel and Associates, Inc.; materials collected by the New Hampshire Historic Bridge Inventory Committee in the late 1980s; and the New Hampshire Historic Bridge Inventory Update. In addition, much of the historical context narrative can be attributed to James L. Garvin, State Architectural Historian at the New Hampshire Division for Historical Resources, and Richard M. Casella, private consultant with Historic Documentation Company, Inc.

The 1982 New Hampshire Historic Bridge Inventory was prepared for several High Pratt Truss bridges within this category. Materials within this collection included geographic information, site plans, elevation drawings, and minimal historic information. Eligibility recommendations were made during this survey, but NHDOT staff did not feel that these findings were accurate. Subsequently, during the mid-late 1980s, a Historic Bridge Inventory Committee was formed to review the material from the 1982 survey and make National Register eligibility determinations. High Pratt Truss bridges were categorized as follows: Single Span High Pratt Truss, Two Span Steel High Pratt Truss, Three Span Steel High Pratt Truss, and Steel Combination Trusses (all of which contained at least one High Pratt Truss as its primary structural member). Additional historical information was gathered and compiled into large binders that discussed each bridge under survey. Fifteen (15) Single Span High Pratt Trusses, two (2) Two Span Steel High Pratt Trusses, one (1) Three Span Steel High Pratt Truss, and four (4) Steel Combination trusses were evaluated (for this current study, all High Pratt truss bridges under these subdivisions were combined to create one type). The structures were rated on an agreed-upon scale in regard to Historicity, Technological Significance and Environmental Quality. Bridges reaching a score of 16 or above were considered eligible for listing in the National Register of Historic Places. Subsequent to the Committee’s review, an additional Single Span High Pratt Truss was discovered. Antrim-Bennington 193/100, a bypassed truss, was evaluated on June 21, 1999 and received a score of 24. The scoring system was later dropped from the evaluation process and each bridge has since been evaluated on a case by case basis.

NHDOT is currently undertaking a Historic Bridge Inventory Update in recognition of the fact that some categories of bridges were not evaluated, many bridges have been demolished, and even more may have deteriorated or been altered since the time of the first survey. This task is multi-faceted and includes database compilation, fieldwork, background research, and form preparation. Information gathered during this current study on the High Pratt Trusses will be incorporated into this document and will be provided on forms that will evaluate each bridge within this category.

The Historic Bridge Inventory Update is intended to be a comprehensive survey of bridges constructed prior to 1961. The survey will investigate many different types of bridges, including High Pratt trusses. As part of this effort, NHDOT staff have compiled a Microsoft Access database that includes all bridges that were evaluated as part of the first survey and all bridges that have been evaluated since the first survey. NHDOT staff compared this database to the Pontis database (the NHDOT system-wide database that includes all state-owned and town-owned highway bridges in New Hampshire) to see if there were additional bridges within the High Pratt Truss category that need to be reviewed as part of this update effort. Only highway bridges are included within this update. Bridges that carry railroads and all culverts were not evaluated as part of the Historic Bridge Inventory Update.
Prior to fieldwork, NHDOT staff located related materials on a specific bridge from existing NHDOT files and other sources. This material includes all information found within the earlier surveys, current inspection reports, and locational data. Fieldwork included digital and black and white 35mm photographs to document the bridge. Information on the bridge's setting (including whether or not it may lie within a potentially eligible historic district) and notes on the condition of the bridge were also taken. This field data was brought back to the office to be incorporated into a Microsoft Access database form for each bridge evaluated. The form contains a description/condition statement and information on the designer, setting, and associated context. NHDOT staff used National Register criteria of eligibility to make National Register eligibility determinations for each bridge, rather than the previously used point system.

The historic context narrative found within this document relies heavily on information compiled by James L. Garvin, Architectural Historian at the New Hampshire Division of Historic Resources in Concord, NH. Mr. Garvin is in the process of preparing a book entitled, *New Hampshire's Highway Bridges: Masonry and Metal* and his unedited draft provided much contextual information. In addition, several Historic American Engineering Survey reports and New Hampshire Historic Bridge Documentation reports prepared by Richard M. Casella of Historic Documentation Company, Inc. provided materials specific to federal law and related twentieth-century bridge construction in New Hampshire.

Single Span High Pratt Truss	
Town	Bridge No.
Stratford-Maidstone	098/064
Milford	062/138
Bartlett	191/139
Bethlehem	127/178
Canaan*	089/034
Greenville	075/114
Henniker	097/101
Plymouth	141/143
Effingham-Freedom	176/185
Littleton	232/050
Northumberland*	106/112
Bartlett*	208/150
Errol*	114/119
Goffstown*	136/106
Littleton*	199/060
Antrim-Bennington	193/100
Two Span Steel High Pratt Truss	
Concord	070/117
Henniker	095/100
Three Span Steel High Pratt Truss	
Hooksett	083/150
Steel Combination Trusses	
Berlin	252/077
Concord*	186/103
Lebanon	058/127
Shelburne	122/110

* No longer extant

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