NEW HAMPSHIRE HISTORIC PROPERTY DOCUMENTATION

LEBANON – HARTFORD BRIDGE
NH BRIDGE NO. 058/127

NH State No. 655

LOCATION: Spanning Connecticut River between the towns of Lebanon in Grafton County, New Hampshire and Hartford, in Windsor County, Vermont.
USGS Hanover, NH - VT, Quadrangle
UTM Coordinates: 18.716597.4836583

BUILDER: New Hampshire Highway Department (NHHD).

ENGINEER: New Hampshire Highway Department staff engineers

CONTRACTOR: Simpson Brothers Corporation, Boston, MA.

FABRICATOR: American Bridge Company, Elmira, NY, plant.

DATE: 1936

PRESENT OWNER: Town of Lebanon, NH.

PRESENT USE: Bridge closed and bypassed with temporary bridge.

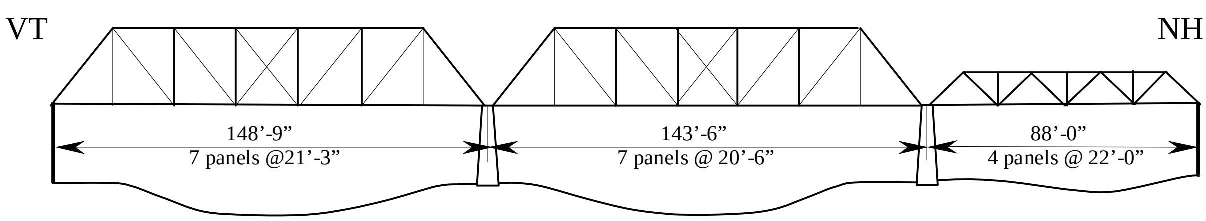
SIGNIFICANCE: The Lebanon-Hartford Bridge is significant for its association with the early transportation history of NH and VT established by the original bridge built at the site in 1805 linking the Fourth New Hampshire Turnpike and the White River Turnpike. It is associated with the history of engineering, representing a well-preserved example of a multi-span riveted truss highway bridge. It is a rare survivor of its type being one of the five remaining bridges of the original sixteen built in NH after the floods of 1927 and 1936. It is associated with the devastating flood of 1936 and the federal relief funds used to construct the bridge. The structure embodies the new bridge design standards developed by Bureau of Public Roads at the time. The stone abutments and piers built in 1892-97 exhibit the high quality of the materials and workmanship of that period. The American Bridge Company, the fabricator of the bridge, has made important contributions to the history of bridge engineering and bridge construction in New Hampshire and elsewhere.

PROJECT INFORMATION: The Lebanon-Hartford Bridge was documented in accordance with the standards of the Historic American Engineering Record in 2011 by Historic Documentation Company Inc. (HDC), Portsmouth, RI, for the New Hampshire Department of Transportation (NHDOT). The report was written and compiled by Richard M. Casella, Engineering Historian, Historic Documentation Company. Charley Freiberg, Elkins, New Hampshire, completed the photographic documentation for the NHDOT in 2008.

DESCRIPTION

The Lebanon-Hartford Bridge (Lebanon 058/127) is a three-span riveted steel truss highway bridge on stone and concrete abutments over the Connecticut River between the settlements of West Lebanon, in the town of Lebanon, New Hampshire, and White River Junction, in the town of Hartford, Vermont (see Figures 1 and 2). The bridge carries US Route 4, classified as an Urban Minor Arterial and a State Bicycle Route, through areas zoned Central Business District along the approaches on both sides of the river. Development along the route, named Bridge Street in Lebanon and Maple Street in Hartford, is characterized by early twentieth century-late twentieth century commercial and residential buildings. The West Lebanon rail yard was located southeast of the bridge but has been dismantled in recent years. A cement plant now utilizes the old railyard area under an agreement with the Claremont-Concord Railroad. A diner, glass company and sporting goods store are also located along the east approach. On the Vermont side near the bridge are the offices of a community services provider and two apartment buildings.

The bridge is 392 feet in length overall, consisting of two high (thru) Pratt truss spans of 143'-6" and 148'-9" and a low (pony) Warren truss with a span of 88'-0". The bridge has an out-to-out width of 25'-2" and a curb-to-curb width of 24'-0". The spans rest on stone abutments and three stone piers, all with concrete caps, that were reused from the previous steel bridge that was washed out by the 1936 flood. The bridge has a vertical clearance of 13'-7" under the two high trusses.



[Drawing source: Garvin, 2008]

Superstructure

The two primary thru trusses are of the Pratt type, a design patented in 1844 by Thomas Pratt and characterized by a straight top and bottom chords connected with vertical posts in compression and diagonals in tension. The pony truss is of the Warren type, designed in England by James Warren and Theobald Monzani in 1848. In its pure form, the Warren truss is composed of a series of connected equilateral triangles, with the diagonals functioning alternately in compression or tension. All loads on the truss produce a compressive stress in the top chord and a tensile stress in the bottom chord. Further discussion of the Pratt and Warren truss types, the two most widely used and modified truss forms, is provided below.

The structural members of the Pratt thru truss are shown in Figure 3. Top chords and inclined end-posts are built-up members consisting of 12" channels joined back-to-back with 18" wide by 5/8" thick cover plates on top and with single 2-1/2" x 3/8" lacing bars on the bottom. The shorter of the two trusses utilizes channels weighing 30 and 35 pounds per linear foot (p.l.f.); the longer truss uses 35 p.l.f and 40 p.l.f. channels.

Bottom chords are also built up members with 12" channels joined with top and bottom tie plates. The shorter truss uses 25 p.l.f. and 40 p.l.f. channels; the longer truss uses 30 p.l.f. and 40 p.l.f. channels. Posts and diagonals of both trusses are 10" wide-flange (WF) rolled members of 33, 37, 49, and 54 p.l.f. weights, except in the center panel which is cross braced with two 10" channels. All structural members are joined with riveted 3/8" gusset plates.

The bracing on both trusses is identical. Portal strut and sway-frame struts are triangular truss frames built of angles and gusset plates connected to the posts. The portal strut is 6'-10" deep; the sway-frames are 5'-2" deep. The upper and lower lateral bracing consist of crossed 4" x 3-1/2" x 3/8" angles.

The Warren Pony truss is located at the eastern end of the bridge and consists of 4 panels each measuring 22'-0" and 11'-0" tall. The structural members are shown in Figure 4. Top chords and inclined end-posts are built-up members consisting of 10" x 25 p.l.f. channels joined back-to-back with 18" wide x 3/8" thick cover plates on top and with single 2-1/4" x 3/8" lacing bars on the bottom. The lower chord consists of two 10" x 21.5 p.l.f. channels in panels 1 and 4 and 10" x 37 p.l.f. channels in panels 2 and 3. The channels are joined with top and bottom tie plates. Diagonals are 10 WF 49#, 10" WF 33#. Posts are 10" WF x 41#. All gusset plates are 3/8" thick.

The floor system of all spans consists of floorbeams carrying seven lines of stringers carrying a reinforced concrete deck. The floorbeams are 33" WF 125# beams. Stringers are spaced approximately 4'-0" on center and consist of 18" WF 47# beams. The original reinforced concrete deck was 7" thick topped with a 2" asphalt wearing-course.

The bridge retains its original guardrails on each side of the roadway, consisting of two lines of steel channel mounted on WF beam posts just inside the truss members. A 6' sidewalk with 5' clearance extends out from the truss on the downstream side, supported on steel brackets. The original armored concrete floor has been replaced with a lighter weight wood floor. The sidewalk has NHHD "Standard Type E" steel railings 2'-8" high, consisting of 3-1/2" pipe hand and toe rails with 7/8" diameter steel rod palings (balusters). Several utility pipes and conduits are suspended under the sidewalk.

In 1976 the bridge was rehabilitated by the New Hampshire Department of Public Works and Highways. The work included replacement of the concrete deck essentially as originally designed, but with typical modern improvements including waterproofing membrane, plastic drainage pipes, and new expansion joints. The existing structural steel was blast cleaned and the deteriorated sections were replaced. Repair and stabilization of the west pier was completed and the entire bridge repainted. The bridge was closed to all motoring traffic but open to pedestrians during the five-month project. The contractor for the rehabilitation was Neil H. Daniels, Inc. of Ascutney, Vermont who submitted a low bid of $283,630.50 for the work.

Since the rehabilitation over thirty-five years ago, the bridge has continued to deteriorate. Inspection reports note that the deck and superstructure are in serious condition and the substructure is satisfactory. There is heavy section loss of the deck and heavy rust and section loss throughout the bottom chord and truss system.

Substructure

The bridge was built on roughly the same alignment as the first bridge at the site, erected in 1805. Garvin notes [1] that

> The irregularities of the truss lengths, and other attributes of the geometry of the bridge, reflect the history of previous bridges at this crossing. The first bridge at this site was built in 1805 and linked the Fourth New Hampshire Turnpike with the White River Turnpike. The New Hampshire legislature chartered a new Lyman's Bridge Company to erect a replacement bridge here in 1836, and this corporation built a covered wooden toll bridge. As noted below under "History of this crossing," the covered bridge was supported by rather crude stone piers in approximately the same locations as the piers under the current bridge. The covered bridge was reportedly destroyed by a freshet in 1896 and replaced in 1896-7 by a steel bridge that was supported by new granite piers in approximately the same location as the piers of the earlier covered bridge. The present bridge stands upon the piers that were built in 1896-7.

The 1896-97 piers and abutments were built taller and much heavier than the preceding structures to carry the new pin-connected steel truss bridge. Following the 1936 flood, the piers and abutments were again modified and fitted with reinforced concrete caps and bridge seats to accommodate the present riveted steel truss bridge. The caps provided the necessary modern design and structural integrity for the much heavier bridge while raising the elevation of the bridge deck by nearly four feet to help protect it from future floods.

The present bridge (1936) is approximately 6 feet wider than the 1897 span. The old abutments were wide enough to accommodate the new concrete bridge seats, but the piers required specially designed caps which incorporated a pair of 33" WF 200# beams that cantilever approximately 4 feet over the downstream side of the piers (see Figure 5).[2] The resulting asymmetrical design of the pier caps is an obvious modification as shown in the documentation photographs following this report.

The piers are massive and precisely built, reflecting the exceptional masonry work found supporting many of New Hampshire's large 19th-century bridges. The piers are constructed of granite ashlar with tight joints and are fitted with angled nosing on the upstream end. The nosing, also called a cutwater or ice breaker, is battered at a slight angle to better resist the impact of ice and flotsam.

The abutment stonework is of a lesser quality than that of the piers. A mix of squared and roughly squared stone with unfinished quarry or split facing is used in both random and even coursing. The joints are fully mortared and it is probable that the stones of the earlier abutments and piers were used to reconstruct these abutments in 1896-1897.

FIGURE 1: Location Map USGS Hanover New Hampshire quadrangle, 1996.

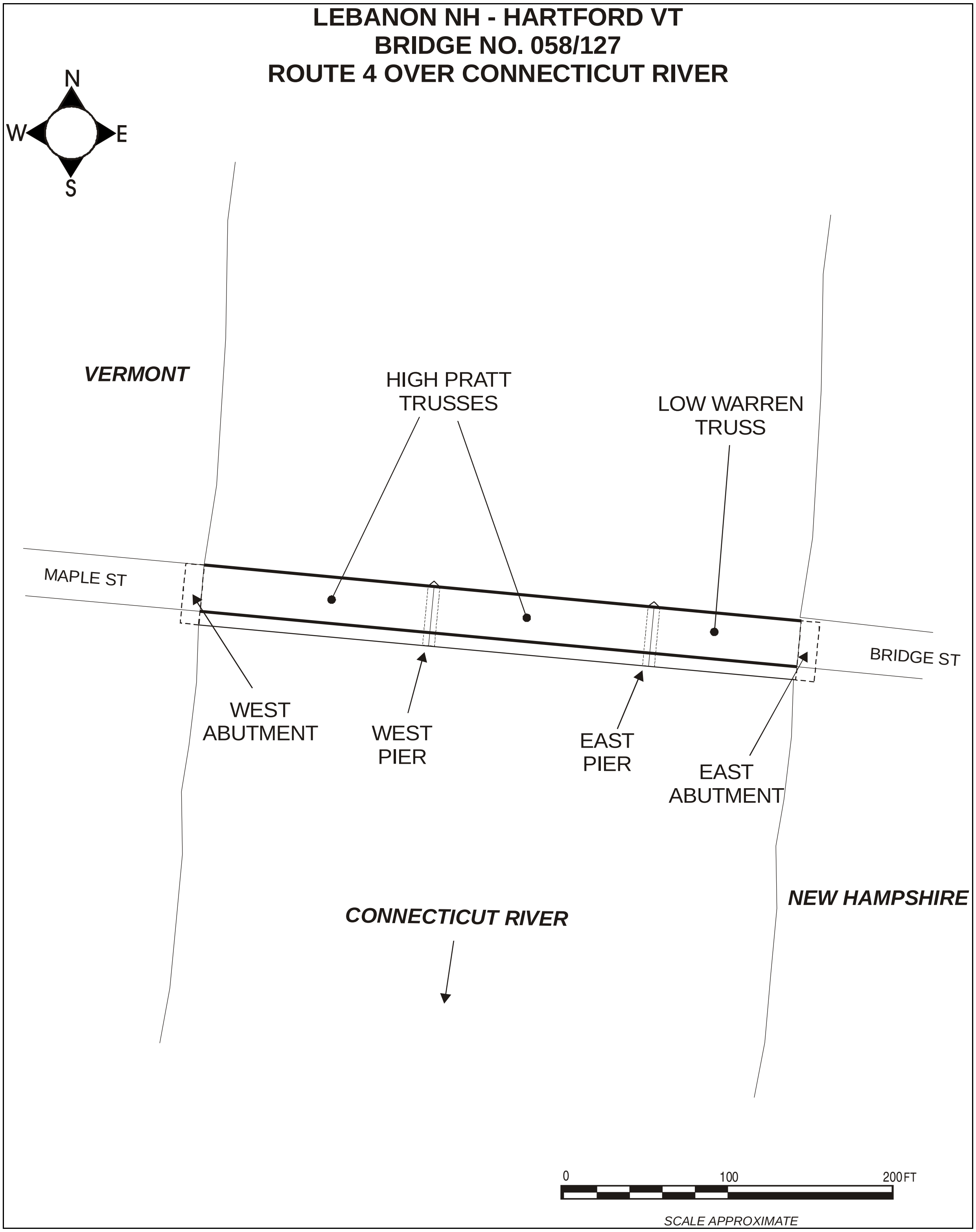


FIGURE 2: Site Sketch

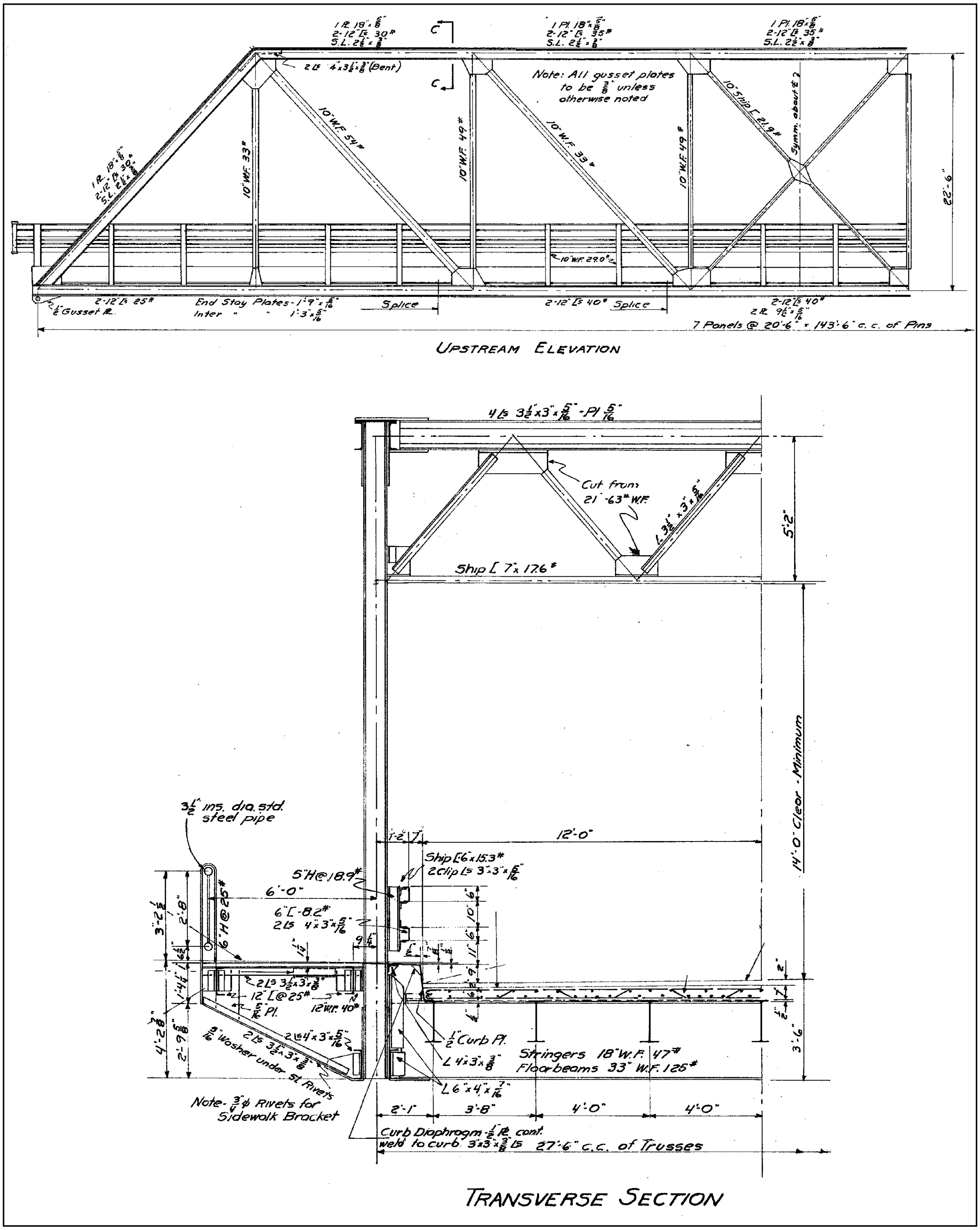


FIGURE 3: Pratt thru truss elevation and section drawings (Source NHHD 1936, Bridge Drawings, Sheet 11 of 21; NHDOT Digital File 50146POP010.tif).

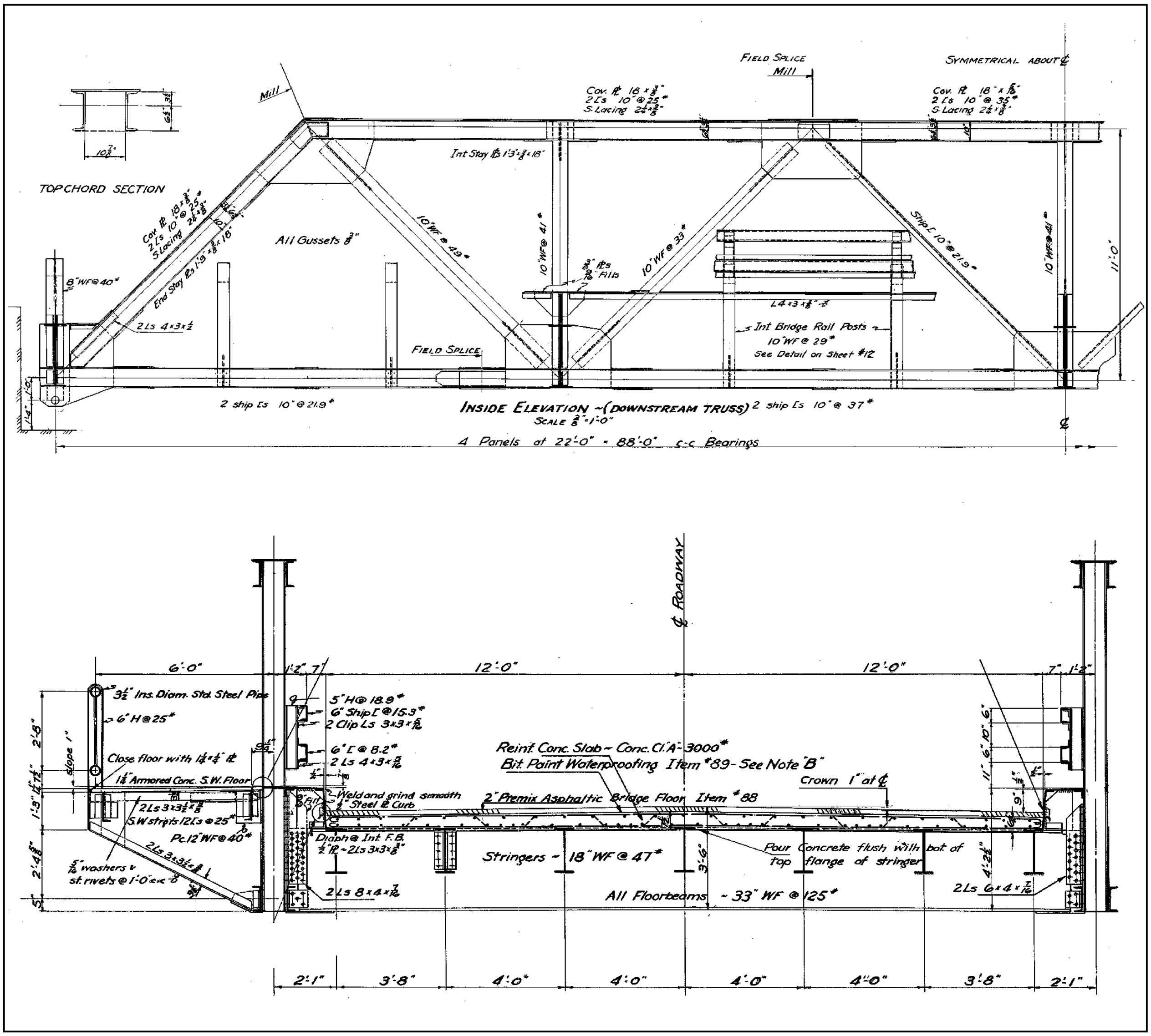


FIGURE 4: Warren pony truss elevation and section drawings (Source NHHD 1936, Bridge Drawings, Sheet 10 of 21; NHDOT Digital File 50146POP009.tif).

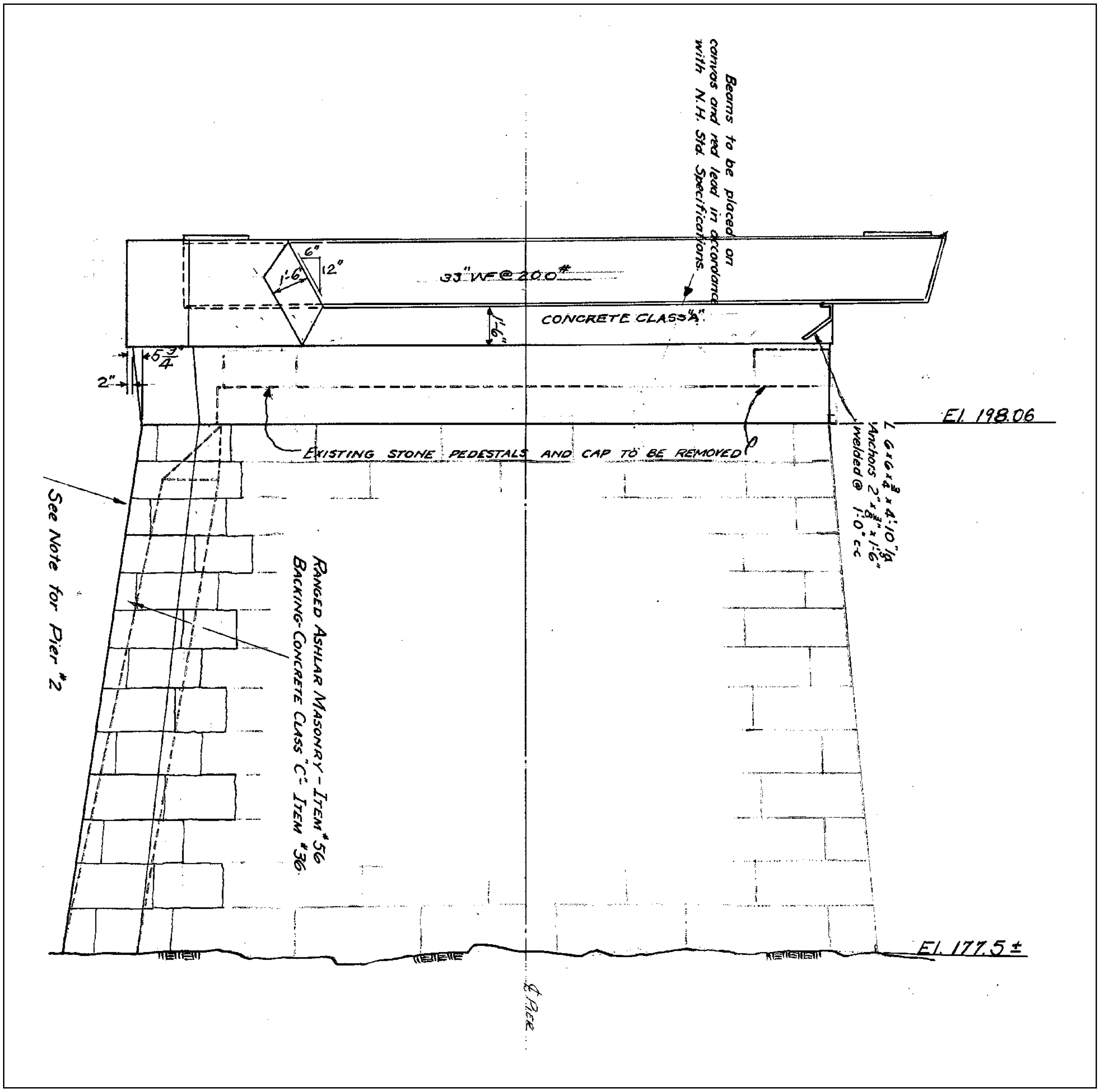


FIGURE 5: Pier 2 (west pier) elevation drawing (Source NHHD 1936, Bridge Drawings, Sheet 7 of 21; NHDOT Digital File 50146POP007.tif).

HISTORICAL BACKGROUND

History of the Crossing and Prior Bridges [3]

This bridge long bore the name of "Lyman's Bridge." It was stated as early as 1881 in the *Independent Statesman*, published in Concord, N. H., that the first Lyman's Bridge "was built under a charter from the New Hampshire Legislature, in 1803, granting to a Mr. Lyman the right to build the only bridge across the Connecticut River between Plainfield and Hanover [N. H.]."[4] No documentation of this purported charter can be found. Among the charters granted by the New Hampshire legislature in 1803, however, was that of the "Proprietors of Lyman Bridge."[5] This act permitted a bridge to be erected across the Connecticut River between Lyman, New Hampshire (which then extended to the banks of the river) and Barnet, Vermont, far to the north of Lebanon. It appears that the name "Lyman Bridge" has been confused with that of "Lyman's Bridge."

In fact, the acts of the New Hampshire legislature that ultimately led to the building of Lyman's Bridge took place in 1792 and 1794. On June 20, 1792, the legislature chartered a corporation that had ambitious plans not only to bridge the river but also to make the White River Falls, which extend from Lebanon north to Hanover on the Connecticut River, more safely passable by river boats. The charter incorporated Ebenezer Brewster, Aaron Hutchinson, and Rufus Graves, together with others who would join them, as "The Proprietors of White-river-falls-bridge." The proprietors were empowered

> to cut canals, and lock all the falls in Connecticut river between the mouth of Mink brook in said Hanover, and the eddy below the lower [rock] bar of white river falls in Lebanon, and likewise [granted] the privilege of building a bridge over said river in any place within the limits aforesaid, not to interfere with private property, or the grant of any ferry without compensation to the owner.[6]

Brewster, Graves, and Hutchinson eventually discovered that their charter of 1792 did not protect the monopoly that they felt was necessary to carry out their plans. Petitioning the legislature, the associates noted that "they have not [been granted] the exclusive right and privilege vested in them their heirs and assigns of erecting and maintaining said bridge, cutting said canals and locking said falls within the aforesaid limits," and that they had not been "empowered to appropriate the lands of private persons (as in the case of highways) for carrying into effect the purposes aforesaid." They therefore petitioned for an amendment to their charter.

On January 21, 1794, the New Hampshire legislature passed "An Act in addition to and [in] amendment of an act entitled 'an act to incorporate certain persons for locking falls, cutting canals and building a bridge over Connecticut river." The new law granted the proprietors a mechanism to lay out roads or towpaths over private property by application to appropriate boards of selectmen, and extended the limits within which they might locate their proposed bridge. The new law provided

> That the proprietors aforesaid their associates, heirs and assigns, be and they hereby are invested with the exclusive right and privilege of erecting said bridge over Connecticut river aforesaid, any where between the mouth of said white-

> river and two miles north of Mink-brook [provided that] in building & completing said bridge, [they] shall not interfere with the grant of a ferry heretofore made to the Trustees of Dartmouth College, within the limits aforesaid.[7]

Charles A. Downs' *History of Lebanon, New Hampshire* makes it clear that the first White River Falls Bridge company was also chartered in Vermont. Downs says,

> October 21, 1795, the Vermont Legislature passed an act incorporating Ebenezer Brewster, Rufus Graves of Hanover and Aaron Hutchinson, Esq., with those who should become proprietors with them, a corporation under the name of The Proprietors of the White River Falls Bridge, by which act they were invested with the exclusive privilege of building a bridge or bridges over the Connecticut River anywhere between the mouth of White River and the lower part of White River Falls on the Connecticut River.[8]

The more constrained geographical limits of the Vermont charter suggest that the proprietors had narrowed the practicable scope of their project by 1795 to approximately the location of the current bridge.[9]

Downs proceeds to show how the Proprietors of the White River Falls Bridge divested themselves of their privilege and how the first bridge, as built, received the name of Lyman's Bridge:

> The above-named persons conveyed all their interest in this corporation to Elias Lyman of Hartford, Vt. Brewster [conveyed his interest on] January 21, 1801, Graves [conveyed his interest on the] same date, Hutchinson [conveyed his interest on] January 29, 1803, to Elias and Justin Lyman, who had then become associated in business.
>
> A bridge was built over the Connecticut by the Lymans on the site of the one now [1908] known as Lyman's bridge, about the year 1802 or 1803. No reference whatever is found on the [Lebanon] town records relative to this bridge.[10]

The *Political Observer* of Walpole, News Hampshire, reported on February 9, 1805, that

> Mr. Elias Lyman of Hartford has erected a bridge across the Connecticut between Lebanon, N. H. and Hartford, Vt. It connects the White River Turnpike with the Fourth New Hampshire Turnpike. Great advantages are promised from this bridge. Its construction is said to be excellent.[11]

Dissatisfaction over the tolls that were charged at this important crossing arose as early as the 1820s. In February 1826, the following petition of two years earlier was printed in the *New-Hampshire Patriot and State Gazette*, published in Concord, N. H.:

To the Honorable Senate and House of Representatives of the State of New-Hampshire in General Court convened.

The undersigned petitioners, inhabitants of the town of Lebanon, respectfully represent, that the bridge across Connecticut River, known by the name of Lyman's bridge, is situated in this town. That the proprietors of said bridge are not, at present, as they believe, authorized by any existing charter, to demand or receive toll of travelers for crossing the same: That the amount of toll is not regulated or limited by any act of the legislature, but depends wholly upon the will of the proprietors: That the original expense of building said bridge did not exceed eight thousand dollars, and that the toll at its present rate, if any fixed rate can be said to exist, amounts annually to not less that fifteen hundred dollars.

It has, therefore, in the opinion of the subscribers, become necessary for the public good, in order to guard against unreasonable exactions in future, that the legislature should interfere and establish a reasonable and uniform rate of toll, and they pray that the same may be established accordingly.

Signed by

Calvin Benton, and others.

Lebanon, Dec. 6, 1824.

STATE OF NEW-HAMPSHIRE.

In the House of Representatives, June 19, 1825.

Ordered, that the further consideration of the petition of Calvin Benton and others for regulating tolls on Lyman's Bridge, be postponed until the second Tuesday of the next Session: That the petitioners and all persons interested, be then heard before the standing Committee on Roads, Bridges and Canals. That the petitioners cause personal notice to be given to the proprietors of Lyman's Bridge, and notice to all others interested, by publishing the substance of said petition and this order, three weeks successively in the New-Hampshire Patriot, the last publication to be at least three weeks prior to said day of hearing.

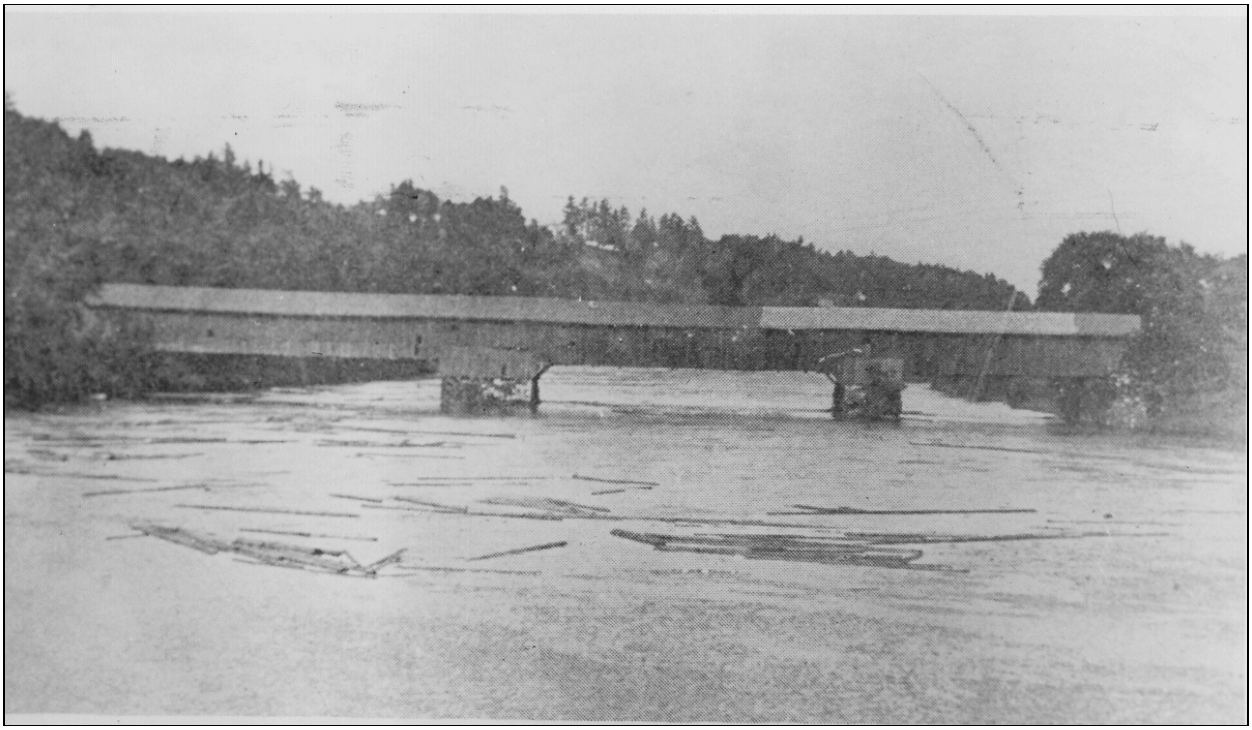
Attest, M. L. NEAL, Clerk

Copy examined by

P. CHADWICK, Assistant Clerk

The outcome of this hearing is unknown, but the original corporation was eventually dissolved and replaced by another.

A new Lyman's Bridge Corporation was created by charter in 1836. According to Downs' *History of Lebanon*, the new corporation was authorized to erect a toll bridge across the Connecticut River between Lebanon and Hartford at any place between the lower rock bar of White River Falls and the southerly boundary of the Town of Lebanon. The bridge that the newly-chartered Lyman's Bridge Corporation erected in 1836 was a covered bridge; its 1805 predecessor had presumably been an open stringer bridge. The covered bridge survived until it was "washed away" in 1896, and is pictured in the book *50 Old Bridges of Lebanon, New Hampshire.*[12] A photograph (reproduced below) is also to be found in the collections of the Hartford, Vermont, Historical Society.



Lyman's Covered Bridge with the Connecticut River at flood stage. Courtesy of Hartford [VT] Historical Society

As noted earlier, the 1836 bridge had stone piers in locations that appear to match those of the current substructure, but these earlier piers were built of native rubble, not ashlar, and the piers were relatively low, leaving the wooden superstructure to be supported well above the top of the stonework by wooden cribs or struts. It is difficult to tell from available photographs how far the covered bridge was elevated above the river, but the bridge appears to have been somewhat lower than its successor of 1897, and much lower than the existing 1936 bridge.

As had been the case in the 1820s, the presence of a toll bridge at this crossing eventually became a serious source of aggravation to the towns of Lebanon and Hartford. In 1866, Asa T. Barron, a well-known hotelier, and Oscar Barron had purchased all the stock of the bridge corporation, thus becoming sole owners of the toll bridge.[13] The various steps that were taken to "free" the bridge, beginning around 1875, are related in some detail in Downs' *History of Lebanon*, and were also reported, with some misunderstandings or distortions, in newspapers of the 1870s and early 1880s. Apart from issues concerning the laying out of a public highway across the bridge and assessing the resulting damages to be awarded to the Barrons, the procedure involved a legal determination of the exact location of the boundary between New Hampshire and Vermont, or specifically between Lebanon and Hartford. Downs reports that the total cost of "freeing" Lyman's Bridge was ultimately about $7,404.

The new bridge of 1897 was built by the Berlin Iron Bridge Company. *Berlin Bridges and Buildings* (Vol. I, No. 7, October 1898) describes a bridge in Lebanon as a "Pratt Truss Bridge consisting of three spans, two 141 ft. long and one 83 ft. long with a roadway 20 ft. wide and one 6 ft. [side] walk."

Piers for the Third Lyman's Bridge under construction in 1896, using part of the covered bridge as support for a derrick, with the temporary bridge downstream. Courtesy of Hartford [VT] Historical Society

The cost of building the Berlin Iron Bridge Company span was shared by the towns of Lebanon, New Hampshire, and Hartford, Vermont, with the latter paying only a small percentage of the cost since the boundary between the two towns (and states) is the western shore of the Connecticut River. The Lebanon town reports for the years ending in February of 1896 and 1897 document the expenditures of that town; similar reports for Hartford are not presently available. The total cost of the new bridge to the two communities was reported to be $40,766.04, with Lebanon paying $32,287.54 and Hartford paying $8,478.50.[14]

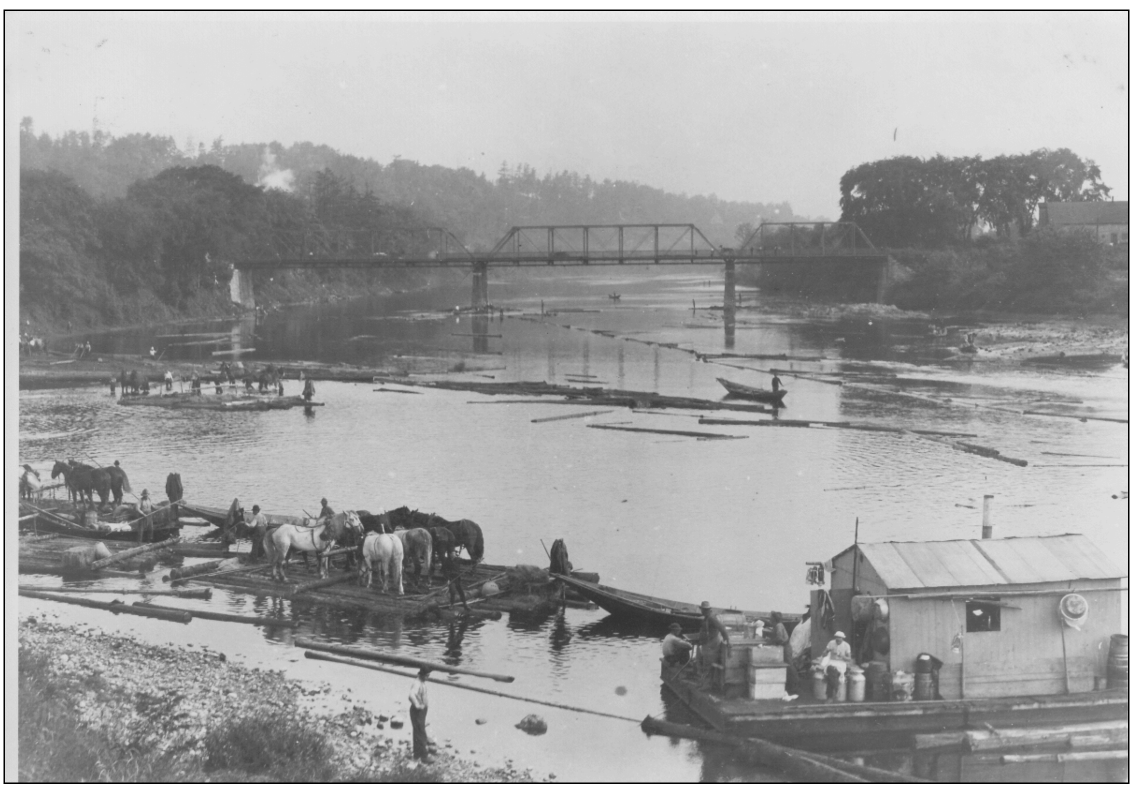
The Lebanon town reports document that town's share of the expenses of constructing the new bridge.[15] The Berlin Iron Bridge Company placed a temporary bridge across the river at a cost to Lebanon of $1,300. The granite abutments and piers were built at a cost of $8,032.16 by the Berlin Iron Bridge Company, with "extra work" (perhaps the provision of the quarried stone) by the George E. Lyons Granite Company at an additional cost of $3,299.96. The substructure must have been placed on deep and substantial footings; the bridge accounts list payments to three men for "use of engine[s] and pump[s]," and George W. Townsend was employed as a diver.

The Berlin Iron Bridge Company received payments of $7,750.00 in 1896 and $10,008.05 in 1897 for the superstructure. Although the Berlin Iron Bridge Company was known for providing bridges of its own design and fabrication, the Town of Lebanon employed its own engineer and inspector for this important structure. The town employed Robert Fletcher as consulting engineer, paying him $232.10 in 1896 and $60.52 in 1897. The town also employed Fred R. French as inspector, paying him $193.25 in 1896 and $17.25 in 1897.

An eminent engineer, Robert Fletcher was born in New York City in 1847, but his parents were both from Vermont. He graduated from the U. S. Military Academy at West Point in 1868, and was immediately hired to teach mathematics at West Point at the age of twenty-one. Sylvanus Thayer, who reformed the Military Academy at West Point and brought it up to the standard of the best military schools in the world, endowed the Thayer School of Civil Engineering at Dartmouth with a gift of $70,000. Thayer is said to have hand-picked Robert Fletcher to direct the Thayer School in 1871 when Fletcher was only twenty-four. Fletcher served on the Dartmouth faculty for forty-seven years, retiring in 1918.

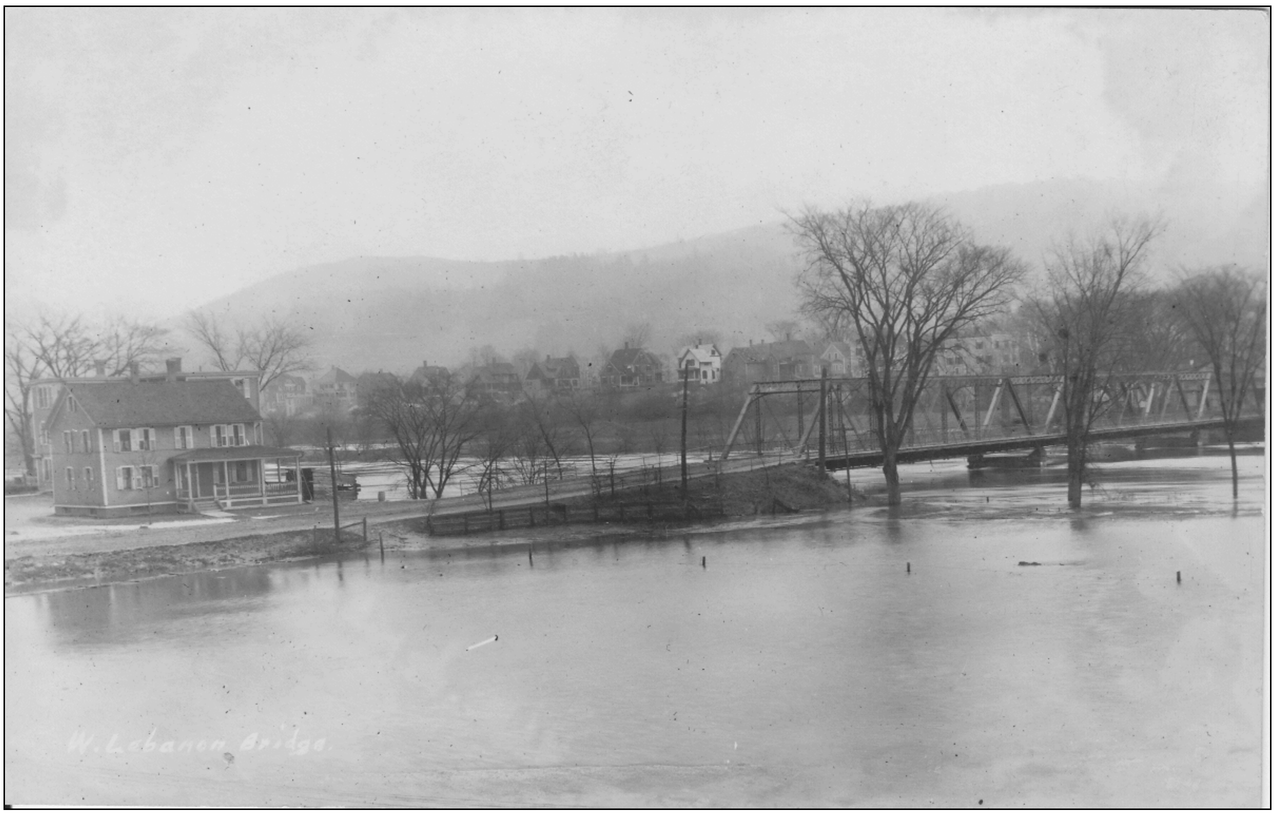
Fletcher and fellow engineer Jonathan Parker Snow collaborated on one of the great documents of bridge building history when they co-authored the paper "A History of the Development of Wooden Bridges," which was published in the *Proceedings* of the American Society of Civil Engineers in November 1932 when both authors were in their mid-80s. This paper is so highly valued as a pioneering study that it was reprinted by the American Society of Civil Engineers in their publication *American Wooden Bridges* in 1976, and in several reprints since 1976.[16]

Given Fletcher's prominence as head of one of the preeminent engineering schools in the United States, it may be conjectured that Fletcher actually designed the third Lyman's Bridge and that the Berlin Iron Bridge Company acted as fabricator and contractor rather than performing its traditional role of purveyor of a structure of its own design.[17]



Third Lyman's Bridge during a log drive, circa 1900. Courtesy of Hartford [VT] Historical Society

Thus far, not much is known about the 1897 bridge. Given the practice of the time, the bridge was probably pin-connected rather than riveted at the panel points. The photograph reproduced above shows no obvious gusset plates at the panel points as would probably be visible in a riveted bridge. The new structure was probably fabricated from steel rather than from wrought iron; the 1906 report of the Bridge Commissioners describes the structure as "a new steel bridge 427 feet long."[18] By the mid-1890s, the Bessemer process for making steel had been introduced into the United States from England and adapted to American ores. This innovation was combined with improvements in the open hearth method, an alternative steel-making technology that was better adapted to ores having the phosphorus content commonly found in North America. Together, these processes brought the cost of "mild" or low-carbon steel as low as that of wrought iron. Once its price was lowered, steel immediately supplanted all other materials for most new bridges. Steel's superior strength and homogeneity opened the possibility of bridges of greater span and complexity, including lift and draw bridges with movable spans.



Post card view of the Third Lyman's Bridge during the flood of November 3-4, 1927.
Courtesy of Hartford [VT] Historical Society

The photograph above, taken during the flood of 1927, almost certainly reveals eye-bars and pinned joints at the bottom chords. At about this time, American engineers began increasingly to employ riveted rather than pinned joints. Pinned joints offer the advantage of accurate structural analysis by elementary methods and ensure simple axial stresses in each truss member, but a pinned truss lacks rigidity under moving loads. A pinned truss also lacks the ability to withstand the failure of a single joint or member. Because an end-pinned member can absorb no bending stresses, failure at a single point in the truss deranges the equilibrium of the entire structure. Such a failure usually results in the catastrophic collapse of the span.

Riveted joints, on the other hand, lock the ends of truss members together by rigid steel gusset plates. This rigidity gives a riveted truss greater stiffness under moving loads. At the same time, a truss with rigidly-connected members develops secondary stresses in its members. Because the ends of the truss members cannot rotate under varying loads, these members assume some bending stresses as well as axial stresses. In trusses of any complexity, these secondary stresses must be calculated and accommodated in the design of the members and the joints. While these added calculations can make the design of a riveted bridge more complicated than that of a pin-connected span, the ability of riveted truss members to absorb bending stresses reduces the likelihood of catastrophic failure of a bridge upon failure of a single joint or truss member.

Although European engineers were building long-span riveted bridges during the 1880s, American engineers did not generally adopt riveted trusses until the end of the century. In part, this was because bridge construction required that much riveting be done in the field as the span was erected. Field riveting requires heating a headed iron or steel plug to white heat in a portable forge, throwing the plug to a pair of riveters working on the structure, inserting the hot plug through pre-punched holes in the structure, and hammering the unshaped end of the plug to form a head like that already formed on the other end. In order to cause both heads of the rivet to clasp the bridge members tightly, one man had to press the headed end of the plug against a member as the other riveter formed the second head.

Until the 1890s, the heading of the unshaped end of the plug had to be done by blows from a sledgehammer on a swage in the time-honored tradition of the blacksmith. Field riveting therefore called for speed, strength, dexterity, and indifference to heights or other adverse conditions encountered in bridge work. Because these conditions could vary widely, field riveting often produced inconsistent results that were of concern to the engineer.

By 1900, development of the pneumatic hammer and portable, gasoline-powered air compressors inspired the rapid adoption of pneumatic field riveting. With such equipment, a hot rivet could be fitted tightly in its hole and given a perfectly-finished round head in mere seconds. Tests showed that such rivets had a high degree of uniformity and a reliable test-strength that made the capacity of riveted connections perfectly predictable by the designer.

The development of pneumatic riveting coincided with the American acceptance of riveted rather than pin-connected bridge trusses for most purposes. By the turn of the century, the riveted steel bridge had replaced the pin-connected wrought iron span in the United States. Boston and Maine Railroad engineer Jonathan Parker Snow, a former student of Robert Fletcher's and the co-author with Fletcher of an important paper on the history of wooden bridges, was one of the most persuasive American proponents of riveted steel bridges.

Flood of March 1936

Hundreds of bridges throughout the northeast United States were built following the floods of March 1936. 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.

> The melting rains coursed off the Appalachian hillsides as if they had been sloping tin roofs. Monstrously gorged rivers roared like millraces and burst their narrow channels. From Maine to Kentucky a vast, swirling chaos enveloped the valley towns and cities. As the rampant rivers tossed off their bridges, gulped in railway roadbeds, swamped highways, transportation throughout the region was practically at a standstill.[19]

The storms' toll on New England was severe: 24 dead, and an estimated 77,000 homeless and $277,000,000 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 extensively from the floods.[20]

The damage to bridges in New England was staggering. Over 700 bridges were replaced or repaired as a direct result of the floods. The work was nearly entirely financed by the WPA and bridge plans accordingly bear the stamp "WPFR" meaning Works Progress Flood Replacement. Twelve new bridges located on Federal Aid highways, seven of which were located in New Hampshire, were built with Bureau of Public Roads funds under the Hayden-Cartwright Act.[21]

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 $2,000,000 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 14 temporary bridges and repair or replace 101 other bridges in addition to the 189 Federally funded bridges built throughout the state.[22]

The majority of the $2,500,000 in damage to bridges in New Hampshire occurred along the Connecticut, Contoocook and Merrimack Rivers, and was the result of the melting of 4' of snow in the mountains above these river valleys. Thick ice carried by the raging rivers scoured the streambeds and banks, plowing over piers and undermining abutments. Damage along the Connecticut River in New Hampshire was particularly severe, the damage exceeding $1,000,000. Five bridges were either washed away or damaged beyond repair and two other bridges required major repairs. Because the state line runs along the Vermont side of the river, the bridges are owned by the New Hampshire.[23]

1936 Flood Damage to the 1897 Lebanon – Hartford Bridge

Flood damage in the vicinity of the Lebanon – Hartford Bridge began reaching a peak on the morning of Wednesday, March 18, 1936. By the afternoon all factories and mills in Lebanon were at a standstill with workers employed on sandbagging operations. A log boom was built around the flooded Clough Lumber yard located upstream of the Lebanon–Harford Bridge "with the hope that it would save the lumber from coming in quantities down the river and crashing into the bridge where the water is nearly up to the bridge flooring."[24] By evening the entire yard was inundated and several piles of lumber were lost even though they were chained down. Four horses and nine pigs were rescued from the stable.

The Lebanon–Hartford Bridge was structurally damaged but not washed away by the flood. The span was initially closed by the New Hampshire State Highway Department pending a detailed inspection. One travel lane was opened to traffic on the Monday following the flood (March 23); the other lane remained closed until a new bridge was completed the following year.[25] On Sunday, July 19, 1936, Mrs. W.L. Grant of White River Junction took a count of the traffic passing the bridge between 1:30 and 4:30 p.m.:[26]

1333 autos from 26 states
28 trucks
3 houseboats
10 taxis
2 motorcycles
1 on horseback
28 foot passengers

Design and Construction of Present Bridge

The design and construction of the new bridge was undertaken by the New Hampshire Highway Department (NHHD) utilizing federal flood relief funding and assigned the project number ER-10-1036 (ER representing Emergency Relief). Plans are dated between June and September 1936 and are noted as having been approved by the U.S. Bureau of Public Roads. The design of the bridge was a collaborative effort of several NHHD engineers. The modifications to the abutments and piers were designed by G.R. Whittum and Wesley E. Haynes. The design of the cantilevered steel beams on the piers to accommodate the increased width of the bridge bearings was done by Haynes. Haynes was also responsible for the pony truss design, all of the bridge bearings, the roadway equipment including expansion joints, scuppers and drains, guardrails, sidewalk structural members and railings. Clifford Broker designed the grading improvements to the roadway approaches, the approach guardrails, and the two High Pratt truss spans.[27] The design plans were checked primarily by G.R. Whittum assisted by Alfred M. Whittemore.

NHHD engineers estimated the total cost of the new bridge at $85,000. The plans also called for the construction of a temporary two-lane bridge alongside the damaged structure, estimated to cost $15,000. Bids were opened at the offices of the NHHD in Concord on October 22, 1936. The low bidder, Simpson Brothers Corporation, 198 Hanover Street, Boston, was awarded the contract in early November. The total cost of the project was $97,978.95, roughly $2,000 less than the engineer's estimate.[28]

The bridge superstructure was fabricated by the American Bridge Company (headquartered in New York City) at the company's Elmira, New York plant.[29] Eighteen shop drawings were produced by the engineering department at the Elmira plant during November and December 1936.

The American Bridge Company was incorporated in 1900 by J.P. Morgan as a consolidation of twenty-eight bridge companies representing eighty-percent of the structural steel fabricating capacity of the United States, immediately making it the largest bridge fabrication and building company in the world. [more on American Bridge Company is presented in the Supplemental Information section below].

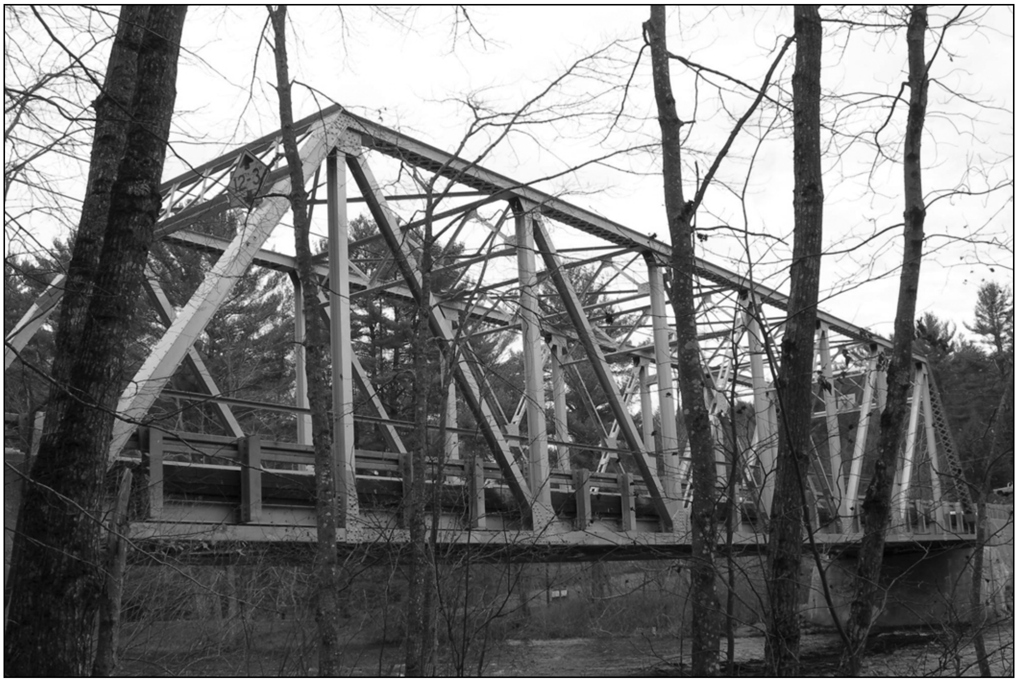
By February 9, 1937, construction of the temporary bridge had been "recently completed" and the contractor was in the process of removing the three truss spans of the old bridge to make way for the erection of the new bridge on the existing abutments and piers. The shorter truss span at the New Hampshire end, and the middle truss span had been successfully demolished. Five workers and a derrick were working on the last span on the morning of February 9th, when at about 11:15 the span suddenly and without warning collapsed into the river. Three of the men managed to leap to the Vermont bank as the span went down and were not injured, but two men went in the river along with the derrick and the truss. Milton DiMone, boss rigger for Simpson Bros., drowned in the accident and his body was not recovered until late in the afternoon. Wilson King, was rescued from the river and treated at Mary Hitchcock Memorial Hospital in Hanover for "immersion and a sprained wrist." [30] The bridge was scheduled to be opened June 1, 1937, although no mention of its opening appeared in the newspapers that were searched for this report.

The bridge was rehabilitated by the New Hampshire Department of Public Works and Highways in 1976 after years of deferred maintenance. Rehabilitation plans included reinforcement of the deck, replacement of deteriorated steel, stabilization of the west pier and painting of the bridge. The bridge was closed to all motoring traffic but open to pedestrians during the five-month project. The contractor for the rehabilitation was Neil H. Daniels, Inc. of Ascutney, Vermont who came in with a low bid of $283,630.50 (according to notes on file at the New Hampshire Department of Transportation).

Comparable Bridges

Lebanon 058/127 is one of about fourteen High Pratt truss bridges built between the Flood of 1927 and World War II. Three bridges remain in existence and in service: Effingham-Freedom 176/185, Greenville 075/114, and Plymouth 141/143; Bethlehem 127/128 has been bypassed. Littleton 232/050 and the subject bridge, Lebanon 058/127, have been approved for replacement and will be demolished. The High Pratt Truss bridges built 1927 to 1940 range in maximum span length from 120’ to 168’. Four bridges were 136’ spans and five were 168’ spans. These bridges are essentially identical in terms of design, materials, fabrication and construction technology.

The surviving bridge most similar to the Lebanon-Hartford Bridge is Effingham-Freedom 176/185 with a span of 136 feet, also built in 1936. It was designed by NHHD engineer H. E. Langley and fabricated by American Bridge Company.



Effingham NH – Freedom ME, High Pratt Truss Bridge (176/185)

Significance

The Lebanon-Hartford Bridge was evaluated according to the National Register of Historic Places Multiple Property Documentation Form entitled, *High Pratt Trusses of New Hampshire 1890-1945*. It was determined eligible for listing in the National Register of Historic Places, meeting the registration requirements under Criterion A, history, for its association with the early transportation history of New Hampshire and Vermont established by the original bridge built at the site in 1805 linking the Fourth New Hampshire Turnpike and the White River Turnpike; and for it association with the 1936 flood and the federal relief funds used to construct the bridge. It was built to replace a bridge destroyed by the devastating flood of 1936, the worst flood on record in New Hampshire.

The bridge also possesses significance to the history of engineering as a well-preserved example of a multi-span riveted truss highway bridge, typical of many built in the U.S. during the first half of the twentieth century. The combination of both rolled and built-up riveted structural members used on the bridge reflects a transition period in steel truss design that occurred during the 1920s and 1930s when the increasing variety of new shapes from steel rolling mills supplanted the labor-intensive built-up members. The relatively heavy sizing of the bridge members in comparison to earlier bridges reflects both the increased dead load due to increased widths and heavier concrete decks, and the increase in load capacity from H-15 to H-20 loading on many bridges during the 1930s. It is also significant for being designed by the New Hampshire Highway Department whose bridge engineers and bridge designs were nationally recognized for exceptional achievement.

The bridge is a rare survivor of its type, being one of the five remaining bridges of the original sixteen built in New Hampshire after the floods of 1927 and 1936 that embody design changes made on a national level by the standards developed by Bureau of Public Roads. It provides an important physical record of the application and adaption of those standards by NHHD engineers to the requirements of each particular bridge design. Although rehabilitated in 1976, the bridge retains integrity of character defining features that include the structural components of the truss as well as the historic stone piers and abutments associated with the establishment of the original crossing.

The present bridge rests on the stone abutments and pier built in 1892-97 for the steel truss bridge that preceded it. The stonework has survived over 100 years of relentless wear and tear by the Connecticut River, testimony to the quality of the materials and workmanship.

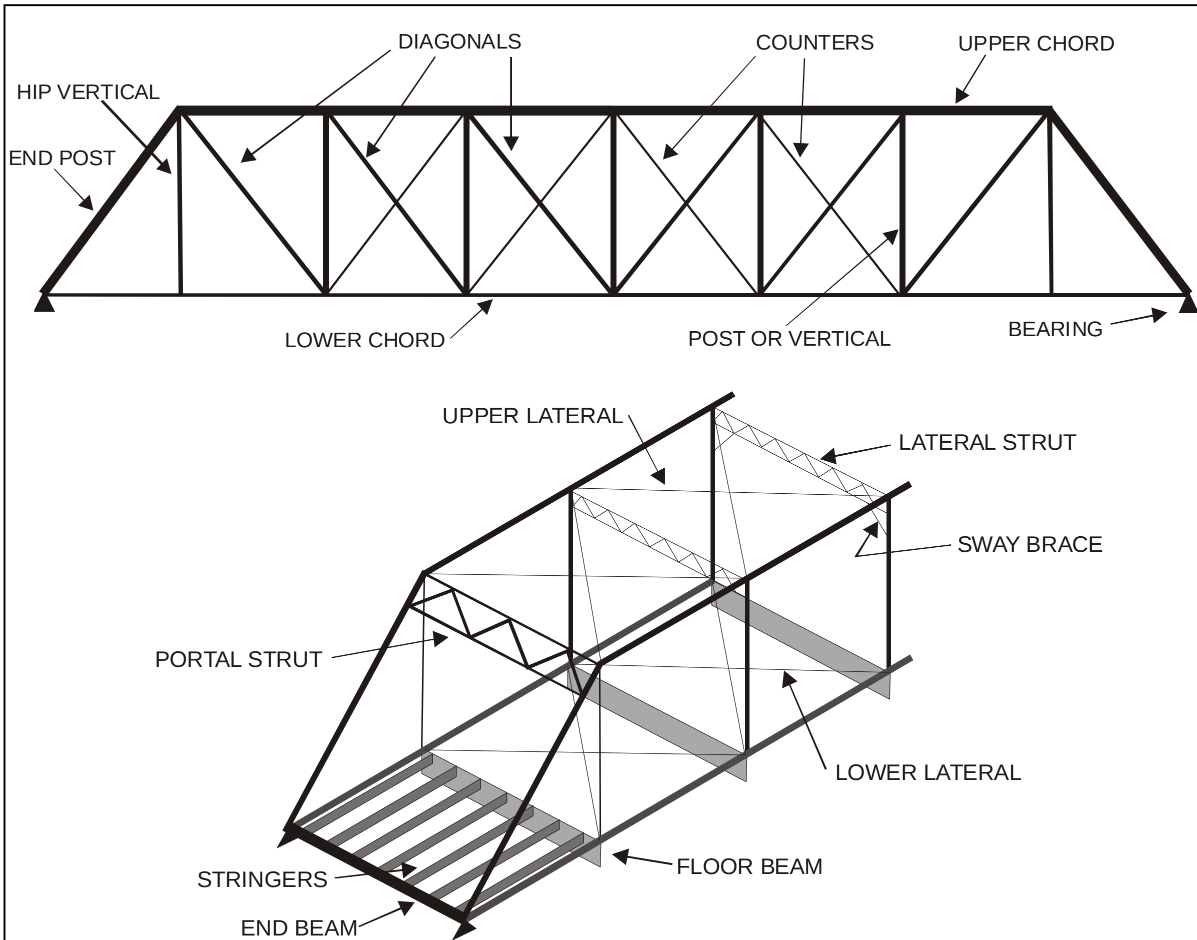
American Bridge Company, the fabricator of the bridge, has made important contributions to the history of bridge engineering and bridge construction in New Hampshire and elsewhere.

SUPPLEMENTAL BACKGROUND INFORMATION

The Pratt Truss

The Pratt truss was designed and patented in 1844 by Thomas W. and Caleb Pratt as a combination wood and iron bridge (US Patent No. 3523).[31] Thomas 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 his entire life in the employ of various New England railroad companies.[32] Pratt is famous for a bridge truss design he patented in 1844, 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 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.[33]

The use of the Pratt 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. By 1889 the truss in its iron form ranked first in usage for railroad bridges. Tens of thousands of bridges, both highway and railroad have been built following the Pratt design or some variation.[34]



High Pratt Truss Bridge Terminology

American Bridge Company, New York, New York, Fabricator

American Bridge has fabricated and erected the steel for a major portion of the world's greatest bridges and tallest buildings.[35] The American Bridge Company was incorporated in 1900 by J.P. Morgan as a consolidation of twenty-eight bridge companies, representing eighty-percent of the structural steel fabricating capacity of the United States. The following year Morgan folded ownership of the American Bridge Company into his newly formed United States Steel Company in the form of a subsidiary. Four other bridge companies were purchased and added to the firm over the years: the Toledo Bridge Company in 1901, the Detroit Bridge and Iron Company in 1902, the Koken Iron Works of St. Louis in 1912, and the Virginia Bridge and Iron Company of Roanoke in 1936.[36]

The company operated out of New York until 1904 when the headquarters were moved to Pittsburgh. In 1902, American Bridge began construction of a huge new plant outside Pittsburgh near the town of Economy, alongside the Ohio River. This facility was the largest of its kind in the world with a structural steel capacity of 20,000 tons per month.[37] The new town of Ambridge was eventually formed around the plant. In 1909 a new ninety-acre fabrication plant was built at Gary, Indiana.[38]

Among the firms acquired by American Bridge were four leaders in the field of movable bridges: the Edge Moor Bridge Works, the Detroit Bridge and Iron Works, the Union Bridge Company, and the Pencoyd Iron Works. American Bridge Company was quickly established as the largest builder of heavy long span movable bridges in the world. This expertise in movable structures helped American Bridge win the contract for the building of the lockgates, dams, shop buildings and other structures of the Panama Canal between 1910 and 1913. [39] By 1926, American Bridge's parent company, U. S. Steel, had become the largest company in the world, with assets of nearly 2.5 billion dollars.[40] During World War II the American Bridge Company was primarily responsible for the nearly two-fold expansion of America's steel industry, regarded as an important factor in the outcome of the War. The company produced over 350 electric steel making furnaces during the war years.

Through the twentieth century many of the original plants acquired at the time of formation of the company were subsequently closed as their equipment and production methods became obsolete. In 1975 American Bridge operated ten plants in the United States located at Ambridge and Harrisburg, Pennsylvania; Antioch, Fresno and Los Angeles, California; Elmira, New York; Gary, Indiana; Orange, Texas; Birmingham, Alabama; Memphis, Tennessee; and Roanoke, Virginia.[41] In 1987 United State Steel sold American Bridge to an employee group. The company was again sold in 1989 to the Ing family of Taiwan who holds the company today as a long-term investment. American Bridge continues to be one of the world's foremost builders of large and complex steel structures. [42]

Simpson Brothers Corporation, Boston, Massachusetts. Contractor

In 1936, this company built a three-span bridge across the Connecticut River between Lebanon and Hartford, Vermont. The bridge incorporates two through Pratt truss spans and one low Warren truss span. In 1937, the firm built a new approach to the Sewall's Falls Bridge (1915) in Concord, composed of ten I-beam stringer spans supported on steel bents. [43] According to the 1925 Boston City Directory for 1925, the Simpson Brothers Corp. was located at 77 Summer Street, Boston.

BIBLIOGRAPHY

American Bridge. Corporate information available at http://www.americanbridge.net

American Society of Civil Engineers (ASCE), "Memoir of Thomas Willis Pratt." *Proceedings of the American Society of Civil Engineers* 1 (1876): 332-335.

Bowman, Waldo G. "Bridge Building Follows Flood." *Engineering News-Record* (July 8 1937): 54-58.

———. "Bridge Engineer's Odyssey." *Engineering News-Record* (July 15, 1937): 104-109.

———. "Bridge Building Down East." *Engineering News-Record* (July 22, 1937): 149-153.

Casella, Richard M. *New Hampshire Historic Bridge Management Plan: Bridge-Type Management Plan for High Pratt Truss Bridges,* June 2011. Report on file at NHDOT.

Chase, Stuart, "Ten Companies Reach Billion Dollar Mark," *New York Times* (March 27, 1927): S8: 1.

Childs, John W., "State Highway Bridge Program 1929," *New Hampshire Highways* (December 1929).

"Chippewa Fall Highway Bridge." *Engineering Record* (January 25, 1902): 78-79.

Comp, T. Allen and Jackson, Donald, *Bridge Truss Types: a guide to dating and identifying.* Nashville: American Association for State and Local History, 1977.

Condit, Carl W., *American Building Art, The 19th Century*. New York: Oxford University Press, 1960.

Fisher, Douglas A., *Steel Serves The Nation.* Pittsburgh: United States Steel Corporation, 1951.

Garvin, James L. *Builders of Bridges in New Hampshire*. Uncompleted draft provided by James L Garvin, Division of Historical Resources, Concord, NH, 1999.

———. *New Hampshire's Highway Bridges: Masonry and Metal*. Unedited draft on file at the New Hampshire Division of Historical Resources, Concord, NH. 1999.

———. "Briefing Paper on the Connecticut River Bridge (Bridge 058/127) on Route 4 Between West Lebanon, New Hampshire and White River Junction in Hartford, Vermont. August 30, 2008." On file at New Hampshire Division of Historical Resources, Concord.

———. "List of Highway Bridges on the Connecticut River Between Vermont and New Hampshire in 1906." Draft document [2004] on file at the New Hampshire Department of Transportation, Concord, New Hampshire.

Granite State Free Press. "Rushing Waters Cause Heavy Damage to Property; Workers Try to Save Dam From Collapse." March 20, 1936.

———. "Flood Damage Here Set at Several Thousands of Dollars." March 27, 1936.

———. "Heavy Traffic over Conn. River Bridge." July 31, 1936.

———. "Bids Opened Yesterday for New Conn. River Span." October 23, 1936.

———. "Contract Let for Conn. River Span." November 6, 1936.

———. "Workman Killed as Bridge Over Connecticut Collapses." February 12, 1937.

Harriott, Donald B. "History of the New Hampshire Highway Department. *New Hampshire Highways* 9 (October 1931).

"Hell in the Highlands." *Time Magazine* (March 30, 1936): 17-19.

Historic Resource Consultants, Hartford, Conn., "Vermont Historic Bridge Survey, Final Report and Preservation Plan" (draft, 1985).

"Kittredge Bridge Company," *New Hampshire Highways* (April, 1931): 17.

Kunz, F. C., *Design of Steel Bridges*. New York: McGraw-Hill Book Co., 1915.

Marden, Walter R. "The Springfield Bridge." *The Engineering Record*, June 13, 1903, p. 634.

Merriman, M. and H. S. Jacoby, *A Textbook on Roofs and Bridges.* New York: John Wiley & Co., 1911.

"Most Beautiful Bridges Chosen for 1931." *Engineering News Record*, June 16, 1932, p. 870.

NHDOT Bridge Files including Bridge Inventory Cards, Bridge Inspection Files and Digitized Original Plans for Lebanon Bridge 058/127. Located at NHDOT Bureau of Bridge Design, Concord.

Pratt, Thomas W. and Caleb Pratt. Truss-Frame of Bridges, Specifications of Letters Patent No. 3,523, dated April 4, 1844. U.S. Patent Office, Washington, D.C.

Scott, Charles. "Ouaquaga Bridge, Historic American Engineering Record No. NY-166. Washington DC: U.S. Department of the Interior Washington, 1987.

Steinman, David B. and Sara R. Watson, *Bridges and Their Builders.* New York: Putnam, 1941.

Stone, Arthur, *The Vermont of Today with Its Historical Background, Attractions and People* (New York, N.Y.: Lewis Historical Publishing Company, Inc., 1929).

Talbot, R. A., *American Bridge Division, History and Organization* (Pittsburgh: US Steel Corp., 1975).

"The New Pittsburgh Plant of American Bridge Company," *Engineering News*, June 26, 1902, pp. 527-528.

Waddell, John A. L., *Bridge Engineering.* New York: John Wiley and Sons, 1916.

NOTES

[1] James L. Garvin. "Briefing Paper on the Connecticut River Bridge (Bridge 058/127) on Route 4 Between West Lebanon, New Hampshire and White River Junction in Hartford, Vermont." August 30, 2008.

[2] The method of placing steel cantilevers across the tops of piers to support more widely spaced bridge bearings "was often used when new superstructures were placed on older substructures after the floods of 1927 and 1936, allowing the new spans to be erected quickly in instances when older piers has survived the floods and were deemed capable of supporting the new spans but were not wide enough for the new structures." (Garvin 2008).

[3] This history section is taken from "Briefing Paper on the Connecticut River Bridge (Bridge 058/127) on Route 4 Between West Lebanon, New Hampshire and White River Junction in Hartford, Vermont," prepared by James L. Garvin, August 30, 2008. Garvin notes, "Various accounts of the history of this crossing make some unsupported statements that confuse the origins of three bridges that preceded the current span. The chronology given attempts to provide documentation for each statement regarding the history of the various bridges."

[4] *Independent Statesman* (Concord, N. H.), September 22, 1881, p. 405, Issue 51, Col. A.

[5] *Laws of New Hampshire*, Vol. 7, Second Constitutional Period, 1801-1811 (Concord, N. H.: Evans Printing Co., 1918), "An Act to Authorize [*sic*] Calvin Palmer and His Associates to Erect and Keep in Repair a Bridge Across Connecticut River," December 24, 1803, pp. 199-201.

[6] *Laws of New Hampshire*, Vol. 6, Second Constitutional Period, 1792-1801 (Concord, N. H.: Evans Printing Co., 1917), "An Act to incorporate certain persons for locking falls, cutting canals, and building a Bridge over Connecticut river," June 20, 1792, pp. 18-20.

[7] Ibid. "An Act in addition to and amendment of an act entitled "an act to incorporate certain persons for locking falls, cutting canals and building a bridge over Connecticut river," January 21, 1794, pp. 133-134.

[8] Rev. Charles A. Downs, *History of Lebanon, N. H., 1761-1887* (Concord, N. H.: Rumford Printing Company, 1908), p. 203.

[9] For a detailed history of the Proprietors of the White River Falls Bridge and their efforts to lock the White River Falls and build a bridge across the Connecticut River upstream at Hanover, see W. R. Waterman, "The Story of a Bridge," *Historical New Hampshire* 20, 1 (Spring 1965): 3-26, and W. R. Waterman, "Locks and Canals at the White River Falls," *Historical New Hampshire* 22, 3 (Autumn 1967): 22-54.

[10] Downs, p. 204. A date of 1802 was assigned to the "Lyman bridge, so called" in the *Report of the Bridge Commissioners of the State of New Hampshire to the Legislature, Dec, 31, 1906* (Manchester, N. H.: John B. Clarke Company, 1906), pp. 4-5.

[11] Quoted in Lyman S. Hayes, *The Connecticut River Valley in Southern Vermont and New Hampshire* (Rutland, Vt.: The Tuttle Company, 1929), p. 160.

[12] *Report of the Bridge Commissioners of the State of New Hampshire to the Legislature, Dec. 31, 1906* (Manchester, N. H.: John B. Clarke Company, 1906), pp. 14-15; Robert H. Leavitt and Bernard F. Chapman, *50 Old Bridges of Lebanon, New Hampshire* (Lebanon: Lebanon Historical Society, 1975), p. 24.

[13] Downs, *History of Lebanon, N. H.*, pp. 305-311.

[14] *Report of the Bridge Commissioners of the State of New Hampshire to the Legislature, Dec. 31, 1906* (Manchester, N.H.: John B. Clarke Company, 1906), pp. 14-15.

[15] The following information about construction of the Berlin bridge is taken from the 1896 and 1897 published town reports of Lebanon, New Hampshire.

[16] The following facts regarding Fletcher may be found in American Society of Civil Engineers, Committee on History and Heritage of American Civil Engineering, *American Wooden Bridges* (New York: American Society of Civil Engineers, 1976): Robert Fletcher, educator, civil engineer. Born New York City, August 23, 1847, son of Edward H. and Mary A. (Hill) Fletcher (both from Cavendish, Vermont). Educated in public schools, the College of the City of New York (three years); U. S. Military Academy at West Point, 1868. Second Lieutenant, U. S. Artillery, serving at Brownsville, Texas and Fort Trumbull, New London, Connecticut. Instructor in Mathematics, U. S. Military Academy, 1869-70. Resigned to become senior professor and director of the Thayer School of Civil Engineering at Dartmouth College in 1871, serving in that capacity for 47 years, retiring in 1918. Consulting engineer on water works and sanitation; engineer in charge of construction of Hanover Water Works, Enfield, N. H., 1893; reservoir for the water works of Hartford, Vermont. Consulting engineer for steel bridges of four [sic] spans each across the Connecticut River at West Lebanon, N. H., and across the White River at Hartford, Vermont. Conducted half of the New Hampshire-Vermont Boundary Survey, 1917. Contributor to technical papers and New Hampshire Bulletins on sanitation and engineering construction. Baptist. Republican. School trustee 17 years; member of the New Hampshire State Board of Health since 1895 (president since 1913); president and engineer, Hanover Water Works Company. Member, American Society of Civil Engineers since 1875. Member and past

president of the Society for Promotion of Engineering Education. Honorary A. M., Dartmouth, 1871, Ph.D. 1881. Married Ellen M. Huntington, July 2, 1872; children: Mary A. Fletcher, Robert H. Fletcher (died 1919). Resided in Hanover, N. H. Died January 7, 1936. The Thayer School at Dartmouth annually confers a "Robert Fletcher Award" in honor of its first dean.

[17] A biographical sketch of Fletcher states that he "designed and supervised the construction of steel bridges across the Connecticut and White Rivers," though it provides no more specific information about these bridges. See William Phelps Kimball, *The First Hundred Years of the Thayer School of Engineering at Dartmouth College* (Hanover, N. H.: University Press of New England, 1971), p. 40. For a thorough summary of the history and practices of the Berlin Iron Bridge Company, see Victor Darnell, "Lenticular Bridges from East Berlin, Connecticut," *IA: The Journal of the Society for Industrial Archeology* 5,1 (1979): 19-32.

[18] *Report of the Bridge Commissioners of the State of New Hampshire to the Legislature, Dec. 31, 1906*, pp. 14-15. This length exceeds the combined length of the three trusses as reported by the Berlin Iron Bridge Company by 62 feet, and may include the raised causeway on the New Hampshire side.

[19] "Hell in the Highlands." *Time Magazine* (March 30, 1936): 17-19.

[20] Ibid.

[21] Bowman, Waldo G., "Bridge Building Follows Flood." *Engineering News-Record* (July 8 1937): 54; Bowman, Waldo G., "Bridge Engineer's Odyssey." *Engineering News-Record* (July 15, 1937): 104.

[22] Bowman, "Bridge Building Follows Flood," p. 54, 56.

[23] Bowman, "Bridge Building Follows Flood," p. 56; "Bridge Engineer's Odyssey," p. 106.

[24] *Granite State Free Press.* "Rushing Waters Cause Heavy Damage to Property; Workers Try to Save Dam From Collapse." March 20, 1936.

[25] *Granite State Free Press.* "Flood Damage Here Set at Several Thousands of Dollars." March 27, 1936.

[26] *Granite State Free Press.* "Heavy Traffic over Conn. River Bridge." July 31, 1936.

[27] For more information on the engineering work of Clifford Broker see: http://www.nh.gov/dot/org/projectdevelopment/environment/units/technicalservices/documents/CliffordBrokerMonograph.pdf.

[28] *Granite State Free Press.* "Bids Opened Yesterday for New Conn. River Span," October 23, 1936.; "Contract Let for Conn. River Span." November 6, 1936.

[29] The original shop drawings are located in NHDOT Bridge Plan file 1-10-2-1. They have been photographically copied and included in this documentation.

[30] *Granite State Free Press.* "Workman Killed as Bridge Over Connecticut Collapses." February 12, 1937.

[31] The role of Caleb Pratt in the design of the Pratt truss is not discussed in the patent or in the technical or historical literature on the subject. Bridge historians have always attributed the design to Thomas.

[32] 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, American Building Art, The Nineteenth Century. (New York: Oxford University Press, 1960): 108.

[33] Condit 1960, p. 109.

[34] ASCE 1876; 334-335; Condit 1960:111, 112, 302; Theodore M. Cooper, "American Railroad Bridges." *Transactions of the American Society of Civil Engineers* 21 (July 1889): 11.

[35] Douglas A. Fisher, *Steel Serves The Nation* (Pittsburgh: United States Steel Corporation, 1951): 181.

[36] R. A. Talbot, *American Bridge Division, History and Organization* (Pittsburgh: United States Steel Corporation, 1975): 7.

[37] "The New Pittsburgh Plant of the American Bridge Company," *Engineering News* (June 26, 1902): 527-528.

[38] Talbot, *American Bridge Division, History and Organization*, p. 7.

[39] Fisher, *Steel Serves The Nation*, p. 182; O.E. Hovey, *Movable Bridges, Volume I.* (New York: John Wiley & Sons, 1926): 107.

[40] Stuart Chase, "Ten Companies Reach the Billion Dollar Mark. *The New York Times* (March 27, 1927): S8: 1.

[41] Talbot, *American Bridge Division, History and Organization*, p. 7.

[42] American Bridge corporate information available at http://www.americanbridge.net

[43] Garvin, James L. "Builders of Bridges in New Hampshire." 1999. Uncompleted draft provided by James L. Garvin, Division of Historical Resources, Concord, NH.

INDEX TO PHOTOGRAPHS

LEBANON – HARTFORD BRIDGE (058/127)
U.S. Route 4 over Connecticut River, between
Lebanon, Grafton County, New Hampshire and
Hartford, Windsor County, Vermont

New Hampshire State No. 655
Photographer: Charley Freiberg
November 2008

NH-665-1	West approach to bridge (Vermont end) showing portal of High Pratt Truss. Looking southeast.
NH-665-2	West portal of High Pratt Truss (Vermont end). Looking east northeast.
NH-665-3	View of bridge in context from upstream on Vermont side. Looking southeast.
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NH-665-18 Sidewalk and railing detail on downstream side. Looking west southwest.

NH-665-19 Overall view of downstream (south) side of the bridge from New Hampshire side. Looking northwest.

NH-665-20 West (Vermont) abutment. Looking northwest.

NH-665-21 Underside showing floor beams and stringers and east pier. Looking northwest.

NH-665-22 Overall view of underside and floor system. Looking northwest.

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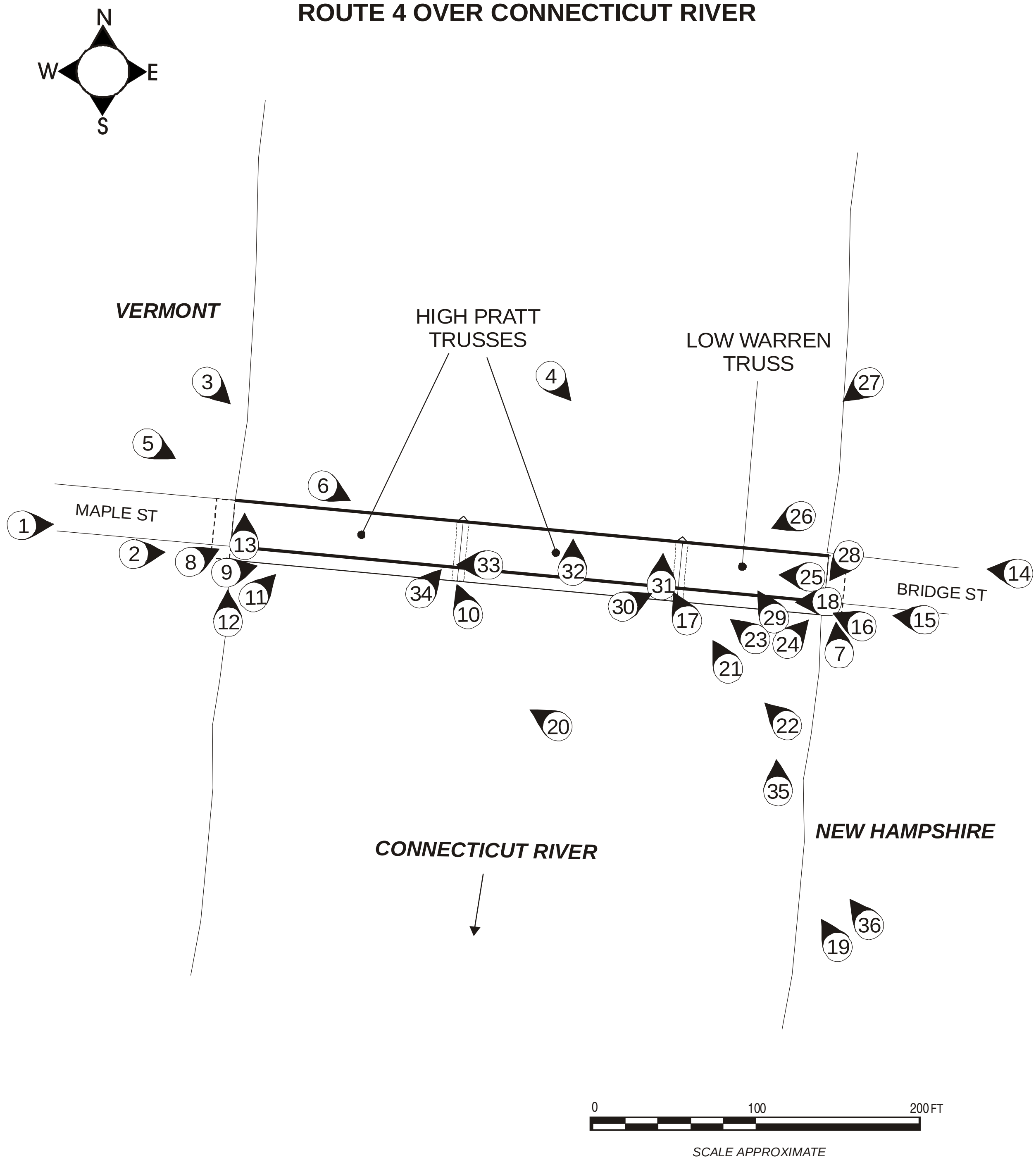
NH-665-36 Overall south elevation of bridge after removal of trees. Looking northwest.

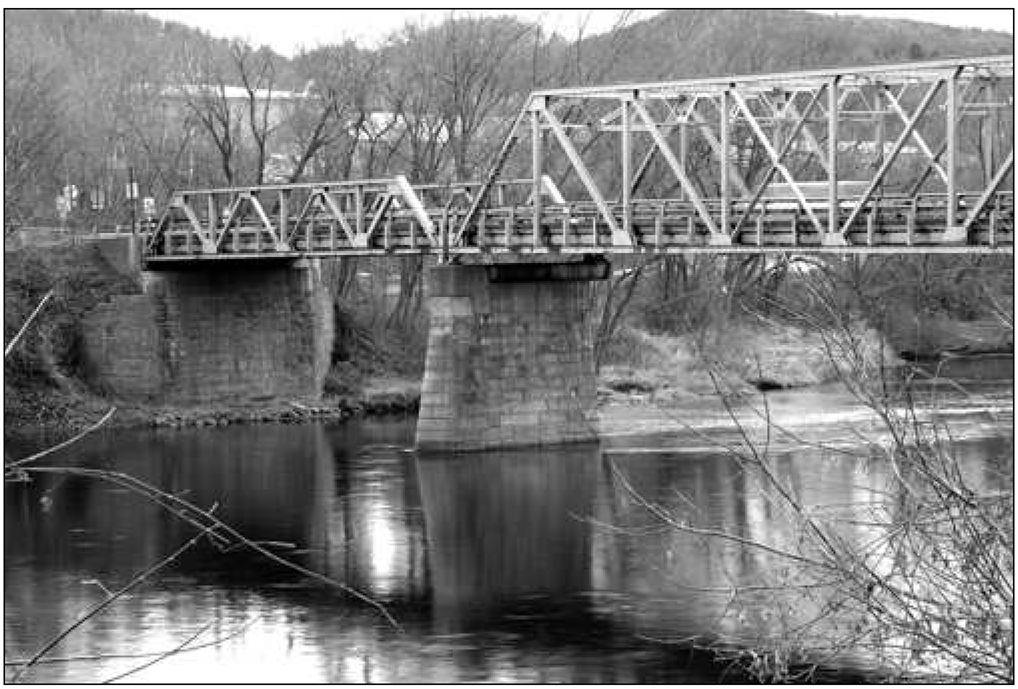
LEBANON NH - HARTFORD VT
BRIDGE NO. 058/127
ROUTE 4 OVER CONNECTICUT RIVER



NH-665-1 West approach to bridge (Vermont end) showing portal of High Pratt Truss. Looking east southeast.

NH-665-2 West portal of High Pratt Truss (Vermont end). Looking east northeast.

NH-665-3 View of bridge in context from upstream on Vermont side. Looking southeast.



NH-665-4 View of Warren Truss (NH end), east abutment and pier. Looking southeast.

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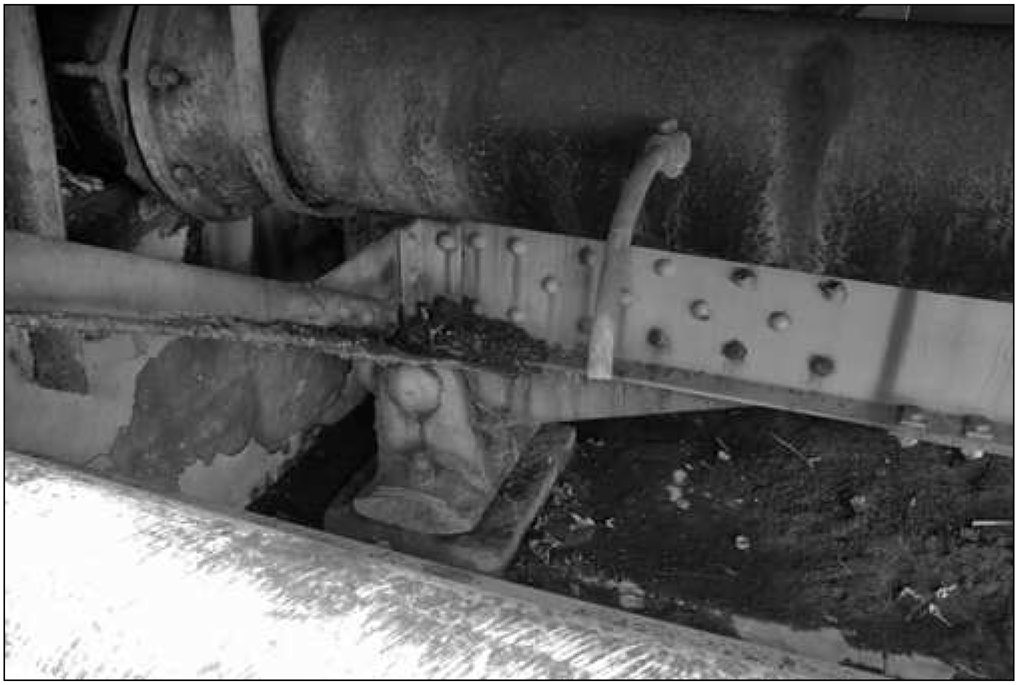
NH-665-11 Underside of sidewalk floor on downstream side from the Vermont abutment. Looking northeast.



NH-665-12 Rocker shoe bearing carrying High Pratt Truss on Vermont abutment, downstream side. Looking north.

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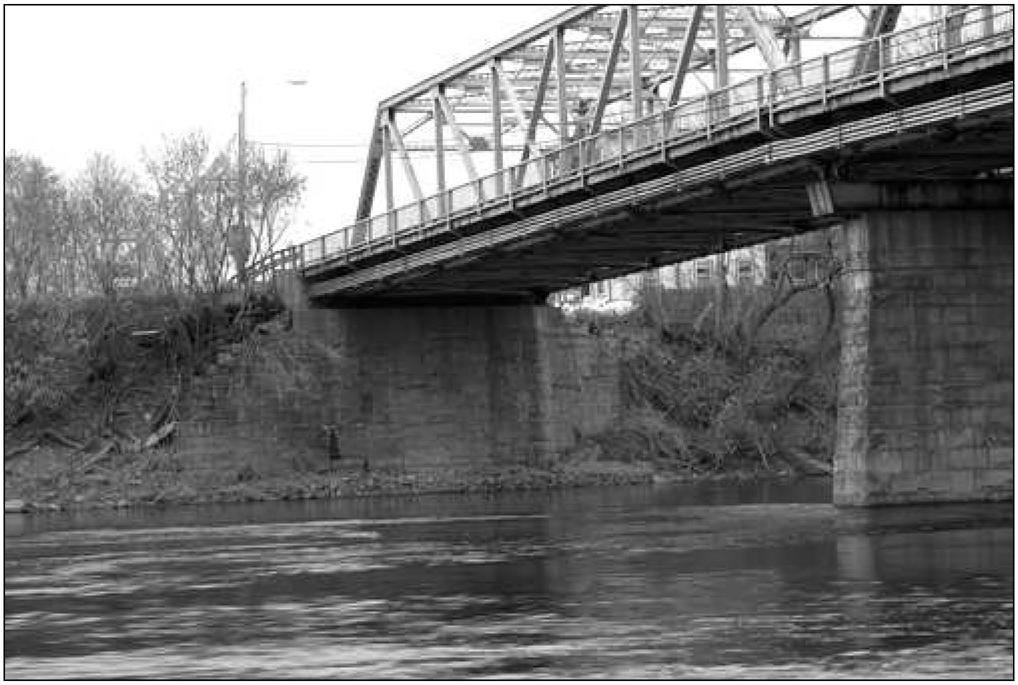

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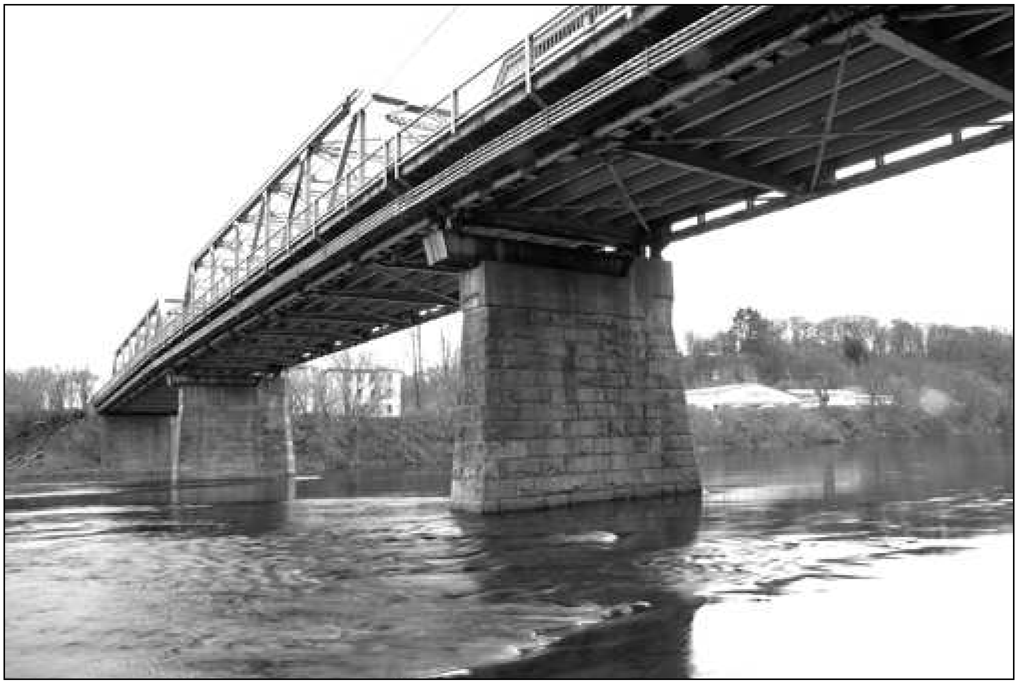

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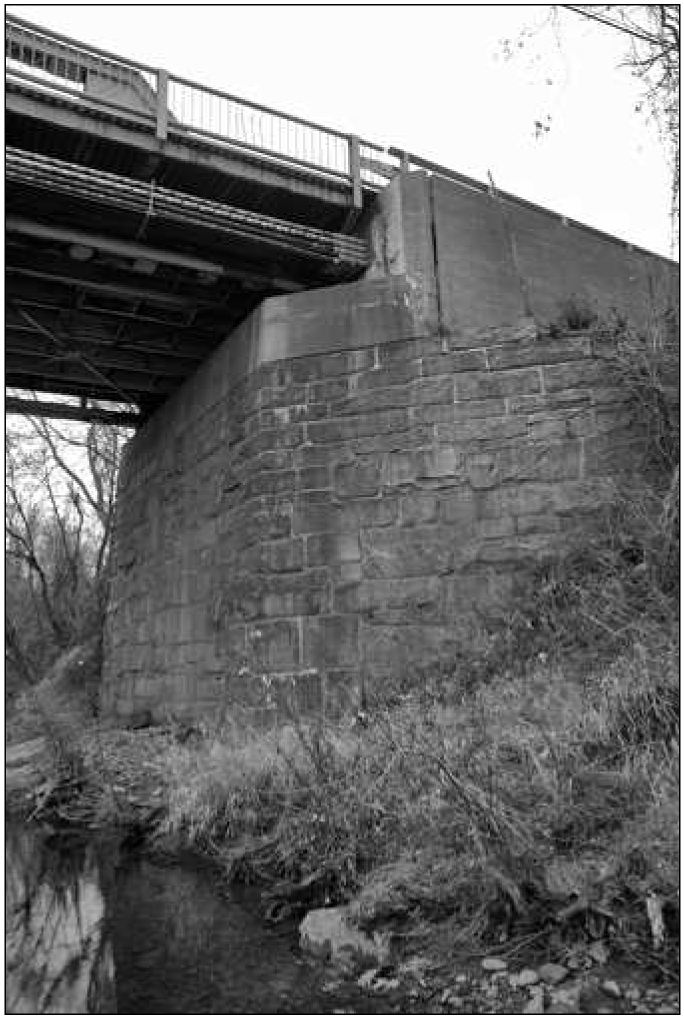
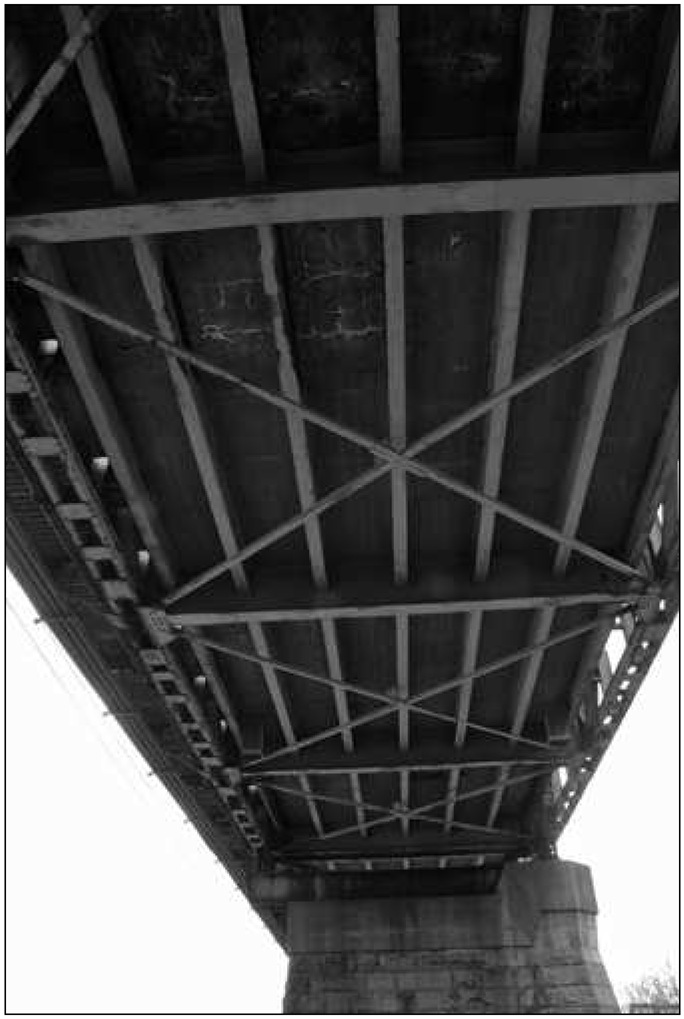


NH-665-24 East abutment showing the south and west faces. Looking northeast.



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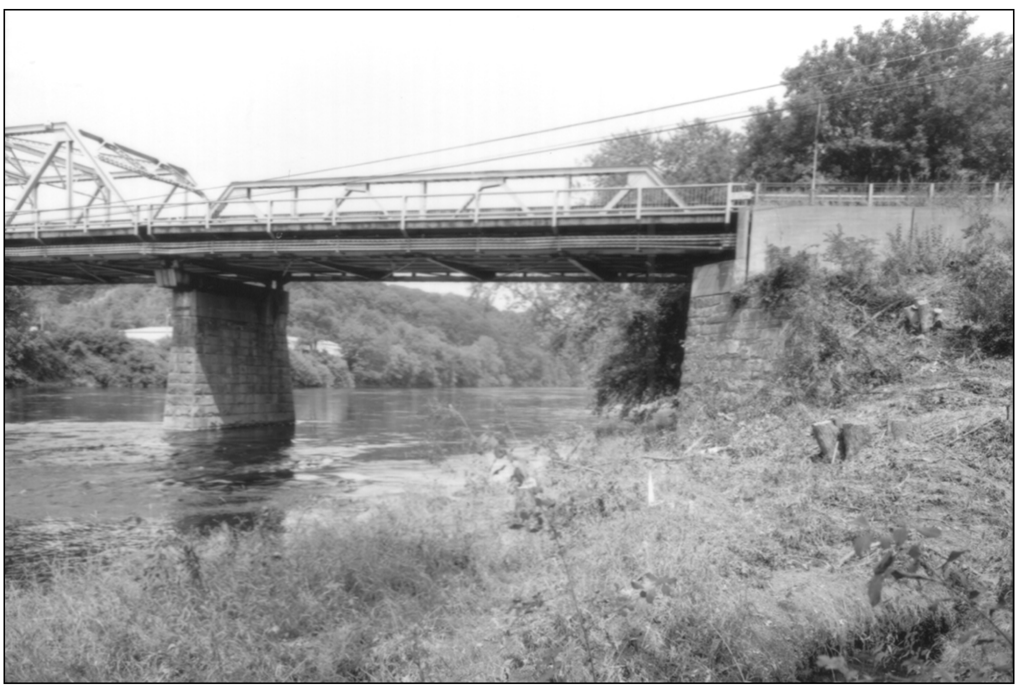

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U.S. Route 4 over Connecticut River
Between Lebanon, Grafton County, New Hampshire and
Hartford, Windsor County, Vermont

New Hampshire State No. 655
Photographer: Charley Freiberg
November 2008

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