Elm Street Bridge
Spanning the Ottauquechee River
Woodstock
Windsor County
Vermont

HAER No. VT-3

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PHOTOGRAPHS

WRITTEN HISTORICAL AND DESCRIPTIVE DATA

Historic American Engineering Record
National Park Service
Department of the Interior
Washington, D.C. 20240

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# HISTORIC AMERICAN ENGINEERING RECORD

VT-3

## ELM STREET BRIDGE

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|---|---|
| Location: | On Elm Street (Vt. Rte. 12) in Woodstock, Vermont<br>UTM: 18.4833440.700190 QUAD: Woodstock North |
| Date of Construction: | 1869-1870 |
| Present owner: | Town of Woodstock |
| Present use: | Highway bridge |
| Significance: | The Elm Street Bridge is an early example of iron highway bridge construction from an era marked by the proliferation of specialized bridge companies. It was built by the National Bridge and Iron Company of Boston and illustrates the degree to which success in this field depended on flexibility of design and efficiency of production. An early example of the use of standardized parts to achieve economy of scale. |
| Historian: | Dennis M. Zembala |
| Transmitted by: | Dan Clement, 1983 |

Until 1870, Nature held the advantage in its contest with man at Woodstock's Elm Street crossing. From 1797, when the first bridge was erected, until 1870, there had been at least seven structures across the Ottauquechee on that site - an average of one bridge every ten years.[1] Shortly after the first bridge was built, the site was acquired by the Royalton and Woodstock Turnpike Company. From 1801 to 1841, this company was forced to rebuild the crossing six times - a fact which may have ultimately led to the company's demise.[2]

There were apparently several reasons the turnpike's proprietors had such difficulty in keeping a bridge at Elm Street. The most obvious is the general susceptibility of wooden bridges to fire, flood, and rot. While there is no record of a fire on any of the Elm Street bridges, at least three were carried away by high water and others became unsafe due to decay. The 1818 bridge erected by William and Barna Raymond rotted and within ten years became a public hazard. In an attempt to force the turnpike company into action, two local men tried unsuccessfully to pry it into the river. It survived until 1827 when it was finally replaced by a covered bridge.[3] While the advent of the covered bridge alleviated some of the problems of rapid decay, it did not eliminate the hazard of flood. Covered wooden bridges floated as well as uncovered ones and the Ottauquechee carried away the Elm Street bridge in 1857 and 1869. The 1857 flood destroyed the southern abutment indicating that the width of the stream bed was too narrow to accommodate the river's flood stages at this point. Following a similar recurrence in 1869 both abutments were moved back a few feet and the southern one raised to provide a channel 14 feet wider.[4]

The reconstruction of the abutments was part of a new, more scientific approach which characterized the 1869 work. Woodstock had become caught up in the sweeping changes which began in the middle of the past century and which, for lack of better term, we call the Industrial Revolution. Within 30 days of the washout, a pile driver had been procured in Boston to rebuild the southern abutment.[5] By mid-November, about 130 piles, "mainly of spruce and twelve to fifteen feet long" had been driven into the sandy soil of the southern bank. Twelve massive, rough-hewn stones were laid on the piles to form the foundation of the abutment. The largest of these was the east cornerstone measuring 12 feet in length and weighing 5 tons.[6] Work proceeded on the abutments until December 11 when winter weather suspended further operations until April 1870.[7]

The superstructure of the new bridge was also characteristic of the new spirit of industrial enterprise which seemed to flower after the Civil War. When a town meeting was held on October 21, 1869 to levy taxes for reconstruction, Charles P. Marsh moved that the new structure be made of iron. (HAER Photo Vt.-3-5) The motion carried and on November 4, the Vermont Standard reported that a contract had been signed with Blodget and Curry, proprietors of the National Bridge and Iron Works of Boston. The contract called for an iron bridge, 110 feet long at a cost of $31 per linear foot or a total of $3,410, FOB, Boston. It was estimated that the cost of erection, freight, and the wood for decking would bring the cost of the superstructure to about $4,000.

Woodstock's first iron bridge is an early example of the spread of iron bridge technology from railroads to highways. With few exceptions, the techniques of iron bridge design and construction had been pioneered by railway engineers during the 1840s and 1850s.* Iron founders, such as Blodgett and Curry, viewed these developments as potential markets for expansion. Bridge engineers saw them as new fields for the application of their specialized talents. Many of the new bridge companies combined the talents of engineers, providing designs based on mathematical calculations, and the iron founder, who carried out the fabrication of the bridge. At the National Bridge and Iron Company, Charles H. Parker was responsible for structural design, while A. W. Parker, presumably a relative, was Superintendent of Works. William A. Blodgett and Cadwallader Curry were "proprietors" and probably exercised financial control. Whatever the division of responsibility at the National Bridge and Iron Company, the physical evidence shows ~~that~~ the two functions were well integrated. The Elm

*A notable exception was Squire Whipple's cast-iron bowstring truss, patented in 1841 and built for crossings over the Erie Canal.

Street Bridge and other designs patented by C. H. Parker display a concern for structural integrity coupled with economy of materials and ease of fabrication. All these factors contributed to the company's success and they built many bridges throughout New England.[8*] (HAER Photo Vt.-3-7)

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*See calling card in file of Division of Mechanical and Civil Engineering, U.S. Museum of History and Technology, Smithsonian Institution, Washington, D.C.; Much research in Boston area sources remains to be done on this important company.

## The Era of Bridge Companies

The period from 1855 to 1875 saw the rise of specialized iron bridge companies which sought to adapt the pioneering work of the railroads for a wider market. Competition between companies and with the carpenter/builders of more traditional wooden forms meant success was usually hard won. Timber was plentiful and local companies were skilled in heavy framing. The companies that survived developed methods to gain a competitive advantage. The basis of most companies was one or several patented designs, preferably of proven reliability. (Although the patent itself was no proof of a structure's safety or dependability, it was probably taken as such by the uninformed.) These were publicized in circulars and catalogues which listed the bridges built and testimonials of satisfied customers. Competing firms hired salesmen to canvass town and county road commissioners in search of likely projects.

The goal of most early bridge companies was to develop a standard design which they could produce in a variety of sizes with a minimum of retooling in the foundry and smithy. The push to keep production costs low was complemented by similar economies in freight and erection. The American system of pin-connected trusses made such structures easy to ship since they could be sent in pieces and erected by pinning the members together at the site. A skilled representative of the company usually supervised an erecting crew comprised mainly of local, unskilled labor. In effect, these iron bridges displayed many of the elements now recognized as typical of an early industrial system of production: mass production of standard parts, prefabrication, flexibility of design and minimum use of skilled labor. A successful company like National Bridge and Iron owed its superiority to the fact that its designs reduced the costs of production and the selling price. While durability was certainly a necessary feature, many successful forms were less scientifically concieved than those which failed.

Parker's 1870 patent, which formed the basis of the Elm Street Bridge, illustrates this trend quite clearly.[10] His claim to priority did not involve the origination of the bowstring truss. That concept had been patented by Squire Whipple in 1841. Rather, he claimed the invention of a sloping end panel in the top chord, a feature which allowed him to vary the length of the bridge, within limits, without changing the rest of the span. In other words, the end panels could be lengthened or shortened to fit a number of sites while the remaining parts could be "mass-produced" from the same patterns. The adjustable span length was a particular advantage where the iron bridge was replacing a wooden bridge and the abutments and span length were determined. This feature resulted in important economies in fabrication because in a bowstring truss any difference in the length of the other panels (all panels equal in length) necessitated a whole new set of diagonal tension rods and vertical posts, no three of which were the same length. Had they been made of cast iron, each bridge would essentially have been a custom-built structure even though it was only a few inches longer or shorter. The savings in production costs from such a system gave the National Bridge and Iron Company a competitive advantage over other bridge companies and the carpenter/builder of wooden structures.

A second improvement and one which increases the significance of the Elm Street Bridge is Parker's extensive use of wrought iron instead of cast. The truss types used by the railroads in the 1850s had timber or cast-iron top chords and posts, but by the mid-1860s, the weakness of cast iron in tension had been established and engineers began to use wrought iron even for members which were theoretically subject only to compression. Parker's design used wrought iron in the arched upper chord member as well as the vertical posts (Whipple's arch consisted of cast-iron perforated panels). Parker's top chord is a built-up member composed of a cover plate and two web plates riveted to two angles (See HAER Photocopy of Patent drawing Vt-3-9), a clear departure from both the hollow, octagonal cast sections of earlier types and the flat perforated panels of Whipple's Erie Canal structures. Built-up wrought iron members were common practice in larger spans by the mid-1870s, but were still unusual in spans of this size.*

Parker also turned to wrought iron for the vertical posts of the Elm Street Bridge, using rolled I-beams with cast-iron connectors at top and bottom. In his patent specifications, he mentioned that these verticals could be composed of either a rolled section as is the case here or of riveted plates and angles. Parker was evidently aware that cast iron members, even when used in compression, were the weakest elements in early iron bridge designs. Although according to theory the verticals were not subject to any tensile forces, in practice there were numerous failures because the bending stresses from moving loads and wind had not been taken into account (these were particularly significant as the mass and surface area increased).**

In spite of Parker's attempt to eliminate cast iron from his design, the few castings he did use illustrate the bridge's transitional role and the premium placed on production economies. The connection

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*The first such members were hollow octagonal sections built up of several rolled wrought iron plates, either bolted or riveted along their length. Both the Phoenix and Keystone iron bridge companies patented their own version.

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**A number of secondary subverticals to distribute the forces more evenly to the arch were also wrought iron. These were not included in the original patent specifications.

between the vertical posts and the arched top chord was achieved by a cast iron eye which was held to the post by a wrought iron strap and received a bolt passing through the chord (see HAER Photocopy of Patent Drawing Vt-3-9, figures 2-5). The strap passed over the eye and was riveted to the web of the I-beam. A second casting at the bottom of the vertical member was open in the center to receive the diagonal tension rods as well. Thirdly, the thrust blocks (or shoes) which formed the connection between upper and lower chord at each end of the bridge were also iron castings (figs. 6-8). The lower chord, a flat riveted bar 6 inches wide, passed completely around the block, while the upper chord butted upon a shoulder at the top. Both upper and lower members were bolted through the block. The use of these three cast-iron connectors was retained for purposes of cost reduction. Compared to the labor and expense involved in machined connections or connections integral with the chords and posts, these castings were much cheaper to produce. This was particularly evident at the thrust block where the angle of entry of the top chord was variable to allow adjustments to the length of the bridge. The only custom work needed here would have been to drill the holes in the member to correspond with those in the shoe.

The fundamental soundness of Parker's design is attested to by the 106 year life of the Elm Street span. Subsequent alterations reinforced the structure to provide for increased loads of highway traffic. Probably around the turn of the century, a steel Warren truss was added below the main structure. In contrast to Parker's original pin connected truss, the latter structure is a riveted truss. It is a tribute to wrought iron's resistance to weathering that the steel riveted structure is in far worse condition than the older, pin connected truss.

Further testimony to Parker's talents lie in the subsequent popularity of the design. Similar bridges were built throughout New England by the National Bridge and Iron Company (See HAER Photocopies... Northfield, Vt.; WV-3-6, WV-3-8.)[11] Perhaps more importantly, this design and others similar to it were successfully adapted to steel structures later in the century and produced widely in larger versions.[12] Hence, the Elm Street Bridge of 1870 is not only an early example of attempts at mass production of iron highway bridges, but also a prototype whose economies in material and in production costs assured it a place in the American landscape for over one hundred years.

## FOOTNOTES



1 Henry S. Dana, History of Woodstock, Vermont (Boston, 1889) pp. 504-507.

2 Douglas Ross, "Full Circle on Turnpikes," Vermonter, Vol. IV, No. 11 (Dec. 1966), pp. 22-29.

3 Dana, pp. 505-506.

4 Vermont Standard, (Nov. 4, 1869), p. 3.

5 Dana, p. 507; Vermont Standard (Nov. 4, 1869).

6 Ibid.

7 Vermont Standard, (April 14, 1870).

8 Richard S. Allen, "Iron Bridges," Vermont Life (Winter 1963) pp. 15-17.

9 See catalogues of Keystone Bridge Company (Phila., 1874); National Bridge and Iron Company, Annual Illustrated Circular (Boston, 1869), The Phoenix Bridge Company, Album of Designs (Phila., 1885); Richard S. Allen, "Iron Bridges," Vermont Life, Winter, 1963, p. 15.

10 Patent 100, 185 (Feb. 22, 1870).

11 Richard S. Allen, "Iron Bridges," Vermont Life (Winter 1963) pp. 15-17.

12 J. A. L. Waddell, Bridge Engineering, Vol. I (New York, 1916), pp. 468-470, Fig. 22eee.

ADDENDUM TO:
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FIELD RECORDS

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