

HISTORIC AMERICAN ENGINEERING RECORD

TAFTSVILLE BRIDGE

HAER No. VT 30

Location: Taftsville Bridge Road, spanning Ottauquechee River, Taftsville, Windsor County, Vermont
UTM: 18.704271.4833988, Quechee, VT Quad.

Date of Construction: 1836

Structural type: Modified multiple kingpost truss with semi-independent arch

Designer/
Builder: Solomon Emmons III

Present Owner: Town of Woodstock, Vermont

Previous and Present Use: Public road bridge since its construction

Significance: Taftsville Bridge is a rare survivor of the early craftsman tradition of wooden truss bridge building. It shows no influence from any of the patented bridge truss designs, but the builder may have been aware of the Swiss tradition from published literature of the time.

Historians: Joseph D. Conwill, Editor, *Covered Bridge Topics*
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Project Information: The National Covered Bridges Recording Project is part of the Historic American Engineering Record (HAER), a long-range program to document historically significant engineering and industrial works in the United States. HAER is administered by the Historic American Buildings Survey/Historic American Engineering Record, a division of the National Park Service, U.S. Department of the Interior. The Federal Highway Administration funded the project.

CHRONOLOGY

- c. 1793 Settlement of Taftsville and construction of the first dam
- 1799 Destruction of Schaffhausen Bridge in Switzerland by Napoleon's army; publicity about Swiss construction in the American press follows
- 1807 First Taftsville Bridge washed out in flood and soon replaced
- 1811 Second Taftsville Bridge washed out in flood and soon replaced
- 1828 Third Taftsville Bridge washed out in flood
- 1836 Solomon Emmons III builds the present covered bridge
- 1869 Bridge damaged in flood and subsequently raised
- 1902 Construction of electric generating station
- 1909 Construction of the present dam
- 1910 Lower chords repaired and iron ties added parallel to the posts
- ? Addition of laminated arches
- c. 1914 Windows cut into siding
- 1952-53 Major repairs and modifications by Miller Construction
- c. 1959 Taftsville Bridge painted red

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Introduction

Taftsville, Vermont, is named for the first settler of the village, Stephen Taft, who arrived from Massachusetts around 1793, although there seems to have been agricultural settlement in the vicinity earlier.¹ He soon built a power dam on the Ottauquechee River, and a factory on the south riverbank to make axes, scythes, and other edge tools necessary in this period of expanding agriculture. His brother Daniel Taft arrived as an apprentice in 1794, and later set up his own business. Meanwhile, Stephen Taft built a sawmill on the north riverbank. Later came a plow and stove factory, a gristmill, a shingle mill, a chair factory, a brickyard, a blacksmith shop, a tannery, and a slaughterhouse.²

Such a busy settlement needed a bridge across the river. The date and style of the first bridge are unknown, but it was lost to a flood in 1807. Floods also washed out two successors in 1811 and 1828.³ These early bridges were likely either trestles, or simple, multi-span truss bridges that were not covered.

The Covered Bridge

Taftsville was ready for a more secure bridge. In 1836, Solomon Emmons III, a prominent local citizen, built the original portion of present covered bridge.⁴ While not a prolific builder, he is known to have built at least one other bridge in downtown Woodstock, Vermont.

The Taftsville Bridge cost around \$1,800 to build, of which almost sixty percent, \$1,050, was for the stonework.⁵ This suggests that the previous bridge was a timber trestle, or that it had only wooden piers. The two new abutments and the center pier were built of dry-laid stone in random courses, and where possible footed directly upon rock ledge.

¹ Stephen Taft is generally cited as the first settler, but Solomon Emmons Sr. (grandfather of the bridge builder) arrived around 1768. See Henry Swan Dana, *The History of Woodstock Vermont 1761-1886*, Woodstock, VT: The Woodstock Foundation, 1980, (original edition, Boston and New York: Riverside Press, 1889), 92.

² An information panel at the north end of the bridge contains much useful information on the area.

³ Dana, *History of Woodstock, Vermont*, 92.

⁴ His father, Solomon Emmons Jr., had married Prudence Taft, sister to Stephen and Daniel. See Pearl G. Watson, *Taftsville Tales*, Taftsville, VT: Happy Valley Homemakers Club, 1967, 50.

⁵ Useful details on the construction of the Taftsville Bridge are found in Richard Sanders Allen, *Rare Old Covered Bridges of Windsor County, Vermont*, Brattleboro, VT: The Book Cellar, 1962, 39-41.

The Truss Design

Taftsville Bridge is a rare survivor of an early craftsman bridge-building tradition, before the time when American bridge construction more or less followed one of the patented designs. The original design (Fig. 1) is hard to classify, but it is probably best described as a modified multiple-kingpost truss. The basic design can be traced back to central Europe in the Middle Ages, having been described by Palladio in 1570.⁶ Various heavy-timbered elaborations appeared in Switzerland. There, the simple queenpost or multiple-kingpost trusses often were combined with a polygonal arch to make an effective, but highly redundant, bridge.⁷

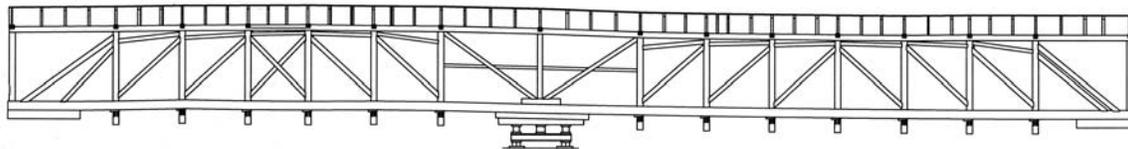


Fig. 1, Taftsville Bridge Modified Multiple-Kingpost Truss, as Built

Covered bridges built in America during the 19th century utilized a variety of structural forms, but most American builders favored simpler framing styles. Theodore Burr received his first patent for the Burr arch-truss in 1817, and Ithiel Town was awarded a patent for his lattice truss three years later. By 1836 there were numerous examples of both structural types across the Northeast, but Emmons rejected them in favor of a non-standard design that more closely resembled some early European bridges. One possible influence on the design was the description of trusses contained in Francis Price's *British Carpenter*, first published in 1733 (Fig. 2). The work was popular enough to go through multiple printings and was in wide distribution throughout America by 1836. The primitive trusses detailed in the pages of Price's work are at least superficially similar to those of the Taftsville Bridge. A second possible influence was the heavy-timbered Shaffhausen bridge, constructed by Hans Ulrich Grubenmann in Switzerland between 1755 and 1757, and destroyed in 1799 by Napoleon's army. It was well publicized and

⁶ See Richard Sanders Allen, *Covered Bridges of the Northeast*, Brattleboro, VT: Stephen Greene Press, 1957, 10-11.

⁷ An excellent source on Swiss practice is Werner Blaser, *Schweizer Holzbrücken/Wooden Bridges in Switzerland*, Basel: Birkhauser, 1982, though this can be a difficult book to find in the United States.

much admired in America by the 1830s, and noted engineer Benjamin Henry Latrobe, Jr., even used it as a model for some early bridges on the Baltimore and Ohio Railroad.⁸

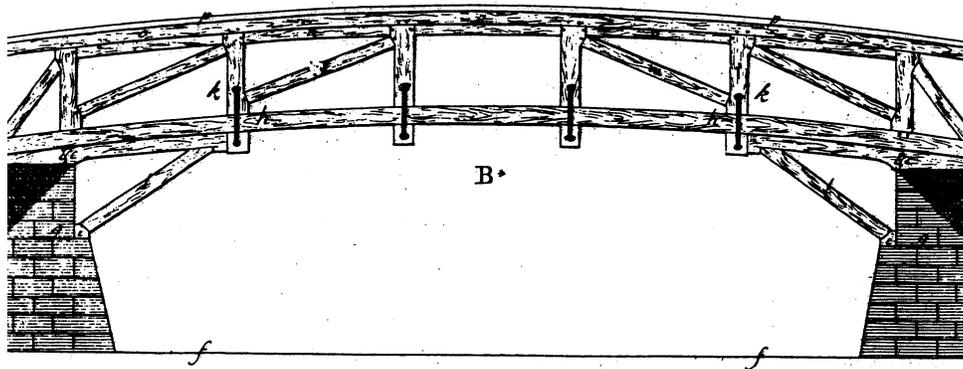


Fig. 2, Plate from Price's *British Carpenter* (1753)

Whether similarities to these antecedents are indicative of their influence or merely coincidence is a matter of conjecture, since Emmons left no record of his education, inspiration, or method. Nor is it possible to study his development through a series of structures, as he had but one other bridge to his credit, several miles downstream in Woodstock, Vermont. That bridge no longer exists, likely having been destroyed by a flood in either 1857 or 1869.⁹

The romantic appeal of covered bridges leads many to assume—incorrectly—that they were built exclusively according to folk traditions. While the image of an isolated, self-taught pioneer devising clever solutions unique to each bridge fits conveniently with American mythology, it obscures the systematic structural thinking that dictated the truss designs used in most of these bridges. There are, however, exceptions, and the Taftsville Bridge stands in stark contrast to the systematic, engineered approach. It is an expression of folk tradition at a time when patented bridge designs were rapidly gaining popularity within the United States.

Framing Details

The lower chords of Taftsville Bridge are of a very archaic style. Unlike those found in covered bridges only slightly more recent, they are not built up using two or more parallel

⁸ Richard Sanders Allen, *Covered Bridges of the Middle Atlantic States*, Brattleboro, VT: Stephen Greene Press, 1959, 21-22.

⁹ HAER no VT 3, 2.

timbers. Instead, they are solid pieces of pine, with mortises cut through for the posts. As described above, two pieces were spliced together with scarf joints near mid-span to make each lower chord.¹⁰

Timber for the trusses was cut and peeled (debarked) from local woods at the rate of one dollar per thousand board feet. Eight large trees went to make the lower chords—imprecisely called stringers in the old accounts—alone. The lower chord timbers were apparently hand-hewn from trees felled close to the original site, despite the probable presence of a sawmill on the site prior to the construction of the bridge. Given their length, it seems reasonable to suggest that they were too large for the carriage of the saw. The appearance of other members in the bridge suggests that they were finished with a reciprocating sash saw,¹¹ but they show considerable variation in dimension nonetheless. The bridge's posts are chestnut, and its diagonals are spruce.¹² The laminated arches, which are such a prominent feature of the bridge today, were a later addition, and they appear to have been machine cut.¹³

Vertical mortises through the lower chords allow the posts to pass completely through the chords. The chords bear down on wedges, which bear in turn on transverse blocks that fit in mortises cut with the grain through each post (Fig. 3). Though a labor-intensive type of joint to make, the wedges allowed the builders to adjust each joint and square the structure to some degree as it was erected.¹⁴ In an attempt to prevent splitting along the grain in the post below the joint (due to shear stress induced by the transverse blocks), a hardwood trunnel was inserted across the grain. In the event of a split, this trunnel could carry some, or perhaps all, of the load, depending on the severity of the split.

¹⁰ Jan Lewandowski, "Agency of Transportation Covered Bridge Report," in Joseph C. Nelson, *Spanning Time—Vermont's Covered Bridges*, Shelbourne, VT: The New England Press, 1997, 155.

¹¹ HAER No. VT 30, 3.

¹² Lewandoski, "Agency of Transportation Covered Bridge Report" in Nelson, *Spanning Time*, 155.

¹³ HAER field notes, June 22, 2002.

¹⁴ Wedges were most commonly used to pre-stress trusses. Applying a tensile load to the posts in this manner places a compressive load on the diagonals that tends to keep the joints tight and rigidize the truss. This use of wedges to pre-stress a truss was a part of Long's patent dated March 6, 1830—six years before the construction of the Taftsville Bridge—but it is not known if Emmons was aware of it. Since many of the timbers are roughly hewn, and wedges are located both above and below the transverse blocks, structural alignment evidently was Emmons' purpose for using this type of joint, and any actual pre-stressing in this case appears to be coincidental and unintended.

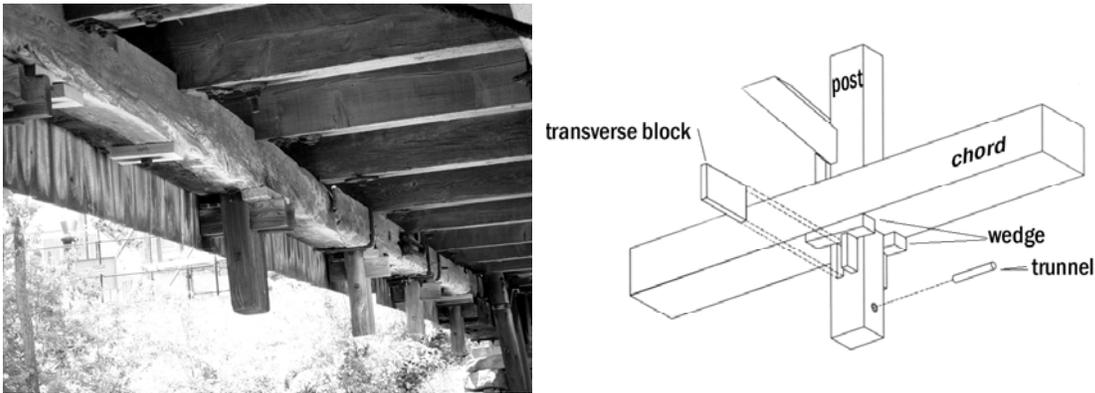


Fig. 3, Wedges in the post-lower chord joints enabled structural alignment

As with many covered bridges, the Taftsville Bridge exhibits considerable random variation in the cross-sectional size of similar members. Posts are around 6-1/2 inches by 11-1/2 inches on average, although posts in the end panels are larger. Braces average around 7 inches by 8 inches, and the timber forming a segment of the polygonal arch in each panel is of similar or slightly smaller size. The outboard end panels have two braces; one perhaps intended as an ordinary brace for the multiple-kingpost truss, while the other completed the rough sweep of the polygonal arch. The end panels over the center pier, while originally built with a single brace each, now feature three apiece. Many of the end braces are rotary sawn, indicating that they were added or replaced at a later date. Panel lengths vary from about 11 feet in the center panels to 16 feet, 6 inches in the end panels.

The total length of the bridge at the floor is 188 feet, 10 inches. The west span (closest to downtown Taftsville) is 89 feet, 1 inch in length, while the east span measures 99 feet, 9 inches. These figures include a small amount of extra housing length at the bridge ends—perhaps a foot—but the exact amount could not be determined without removing the shelter panel boarding. The portals are overhung about five feet, although the exact figure varies from one end to the other, so the roofline is close to 200 feet long. The difference in the span lengths is apparently the result of riverbed conditions that dictated the best placement of the center pier.

The upper lateral bracing does not include a horizontal X form for stability. Instead, the lateral tie beams have short diagonal braces on each side connecting to the upper chord of the truss. The floor no longer has any lateral bracing, but empty dap cuts in the lower chords are evidence that X braces probably were a part of the original design. The floor beams, which are not original, rest atop the lower chords and measure about 7-3/4 inches by 13 inches.

Maintenance and Modifications

By a geographical coincidence, the Taftsville Bridge was located at the corner of three different towns, and it served an important portion of a fourth. Thus, maintenance costs were apportioned among these towns as follows: Woodstock, 18/40; Hartford, 11/40; Pomfret, 8/40; and Hartland, 3/40. An 1851 act of the Vermont legislature made town-limit changes that shifted fifteen acres at Taftsville from Hartland to Woodstock, which put the bridge entirely within the limits of Woodstock. Nevertheless, the other towns continued to make contributions to its maintenance according to the old formula as late as 1908.¹⁵

The present configuration of the Taftsville Bridge is the result of several significant alterations performed over the course of more than 150 years. The original builder, Solomon Emmons III, maintained the bridge from its construction until his death in 1869, after which his son, Captain Edwin Charles Emmons, assumed responsibility for its upkeep through 1898. Altogether, the Emmons family was involved with the structure continuously for over six decades.¹⁶

The younger Emmons raised the bridge approximately three feet in 1869, following a flood that damaged the south abutment and a bottom chord. Stone was added to raise the two abutments, but not the central pier. It received wood cribbing on top of the existing stonework to reach the new height.¹⁷

A second major intervention occurred in 1910, when the scarf joints in the bottom chord were reinforced. Vertical iron ties were added near each post, and parts of the bottom chords adjacent to the abutments were replaced. The cost of these repairs totaled \$1720.¹⁸

By far the most obvious and significant change was the addition of laminated timber arches to supplement the trusses. These arches clearly were added sometime after the bridge's initial construction, but their date of installation is uncertain.¹⁹ Those in the

¹⁵ Most writers assume that the 1851 town limit changes left Woodstock entirely responsible for maintenance, but later Town Reports make it clear that the old arrangement continued. The 1909 report, for example, records small payments from Hartland and Pomfret, their shares still being reckoned as 3/40 and 8/40 respectively. Reports generally covered activity for the previous year. The Pomfret border was three-quarters of a mile away, but the Taftsville Bridge still served the entire southeast corner of the town.

¹⁶ Jay Morgan, Woodstock Town Clerk, and Don Wickman, Librarian/Archivist with the Woodstock Historical Society, furnished data on the Emmons family. The 1898 Town Report is the last one to record a payment to E. C. Emmons—\$4.60 for snowing the bridge. The 1899 report contains nothing about the bridge, and reports from 1900 on show maintenance payments to one Enos Dole.

¹⁷ Richard Sanders Allen, *Rare Old Bridges of Windsor County, Vermont*, Brattleboro, VT: The Book Cellar, 1962.

¹⁸ This kind of iron joint was published for the first time by J. Parker Snow in 1895. See HAER No. NH 38, Contocook Bridge, and Snow, J. P., "Wooden Bridge Construction on the Boston and Maine Railroad."

¹⁹ The date when the laminated arches were added remains the great unknown of Taftsville Bridge's history. Estimates range from a couple of decades after construction, to as recently as about 1914. It is even conceivable that the two spans' arches may not have been added at the same time. The set of Town

south span are ten-ply with a built-up dimension of about 9-1/4 inches by 27-1/4 inches, while those in the north span are twelve-ply and total 9-1/4 inches by 32-1/2 inches. Although the north span is longer, its arches are considerably lower than those in the south span. The arches themselves are approximately the same height from feet to arch apex, but the feet of the north arches sit lower on the pier and abutments. In the middle two-thirds of each span, hanger rods from the arches support the same floor beams that bear on the lower chords, thus relieving some of the load from the truss. Unlike a Burr arch-truss, these arches are not connected directly to any truss members, so they do not interact directly with the trusses. The portion of the load each carries is transmitted from the floor through hanger rods to the arch, thence directly to the abutments and pier. The addition of these arches probably occasioned the removal of some of the sway bracing between the posts and tie beams, which may have been the cause of distortion trouble later on.

The sides of the bridge were originally solid planks without windows, making the inside very dark. Beginning about the turn of the twentieth century, the town regularly paid \$9 per year to Woodstock Electric Company for lighting.²⁰ About 1914, long windows were cut in the siding, and the bridge is now quite bright. An inspection in 2003 suggested that pieces of diagonal timbers that once stiffened the floor laterally—timbers possibly removed to facilitate installation of the arches—were reused as nailing support for the siding, leading to conjecture that the present siding, with its window openings, may have been installed at the same time the arches were added.

During the 1920s, the sides of the bridge's west span began to lean considerably, probably due to the earlier removal of diagonal bracing between the posts and tie beams during the installation of the arches. At the recommendation of an engineer from Springfield Massachusetts, iron rods with a turnbuckle were attached from a timber under the roof to a ledge in the river in order to pull the bridge back into plumb.²¹ How long this fixture remained in place is not known, but the permanence of the river anchorage point, which can still be seen, suggests that it may have been intended to be more than a temporary expediency. Nevertheless, it was removed at some later point, and a July 2004 inspection showed the bridge was again leaning.²²

From December 1952 through March 1953, Miller Construction of Windsor, Vermont, used the frozen river as a platform to raise the bridge another foot, reinforcing the abutments and central pier with concrete caps. Following these alterations, Miller made various repairs to the lower chords and installed new steel gussets between the posts and

Reports consulted is incomplete, and research is complicated by the fact that for some years there were separate reports for Woodstock Village and the Town of Woodstock. A 1913 mandate concerning minimum load ratings for state highway bridges in Vermont and New Hampshire offers plausible, but far from certain, evidence that the arches were added soon thereafter to meet the new requirements. Also see Pearl G. Watson, *Taftsville Tales*, 51.

²⁰ Town Reports generally show this expense from 1898 onwards.

²¹ Pearl G. Watson, *Taftsville Tales*, 51.

²² Field observation by Joe Dahmen, July 2004.

roof tie beams (Fig. 4). Finally, the bridge floor was augmented with a new layer of tread timbers installed perpendicular to the existing ones.²³ The wooden roof shingles were replaced with a metal roof in 1959-60, which was itself replaced in kind in 1993. During the late 1980's so-called "distribution beams" were installed along the tread centerlines beneath the floor beams.²⁴ These distribution beams, overlapping 8-inch by 16-inch timbers, apparently were an attempt to stiffen the floor, but given the relatively short lengths of each timber and the number of joints, their effectiveness is difficult to assess. Repairs to four horizontal tie beams under the roof were necessary in 1993 after a tall van passing through the bridge destroyed them.²⁵

Originally unpainted, Taftsville Bridge received a coat of red paint around 1959. Although some covered bridges were always painted, many received red paint for the first time in the 1950s, perhaps because of the influence of Christmas card views and other Americana showing red covered bridges.²⁶

The Taftsville Bridge in Context

Taftsville was an industrial and commerce center long before the covered bridge entered service in 1836. During that time, Vermont was in the midst of the merino sheep-raising craze. From the 1860s on, dairying became a prominent agricultural activity.²⁷

The Woodstock Railway arrived in 1875, and trains served Taftsville until 1933. For some years in the 1960s the old TAFTSVILLE station sign was mounted on the covered bridge's portal. It was later replaced with a more modern sign, which later vanished.

Manufacturing gradually disappeared, but the dam on the Ottauquechee River still generates power. The Woodstock Electric Company, established in 1893, bought the water rights from the former Taft Scythe Works.²⁸ The company built a combined steam and hydroelectric generating station in 1902, then replaced the old wood-crib dam with the present concrete structure in 1909. The steam equipment was removed in 1916, but in 1942 additional hydroelectric facilities were added. In 1956, Central Vermont Public Service took over the site, which presently has a 500-kilowatt turbine, and it generates enough electricity for about two hundred houses. This is the last remnant of the industrial activity begun by Stephen Taft around 1793. Today, tourism accounts for a sizable share of the area's economy.

²³ Rhoda W. (Teagle) French, "Historic Taftsville Covered Bridge Under Repair," Woodstock, VT: *Valley News*, 1952.

²⁴ Nelson, *Spanning Time*, 156.

²⁵ Ed Barna, *Covered bridges in Vermont*, Woodstock, VT: The Countryman Press, 1996, 149.

²⁶ Nearly the entire stock of covered bridges in Columbia County and in Washington County, Pennsylvania, received red paint at this time. It was a dramatic change. Even the interiors were painted red in Washington County.

²⁷ In addition to the information panel at the north portal of the bridge, a historic marker at the power plant furnished useful background material.

²⁸ Taftsville Historic District registration form, National Register of Historic Places.

From an engineering standpoint, the Taftsville Bridge, with its unusual design and modifications, may well be in a class all its own. While alterations to covered bridges are common, and are to be expected with any bridge of this vintage, the vast majority of surviving bridges were originally built and later altered by individuals who, if not actually trained as engineers, evidently possessed considerable knowledge of structural principles, and their designs reflected that knowledge. Even modified, these bridges usually consisted of members that were assembled into a single, interlocked truss or arch-truss with members whose stresses could be calculated with reasonable accuracy. Except for gross modifications that, for all practical purposes, built a new bridge inside an existing shell in an attempt to obtain a modern bridge while maintaining some odd sense of esthetics, the original truss designs were generally retained, even though certain members might be replaced with larger ones or have reinforcements added.

This has not been the case for the Taftsville Bridge. While it may appear to be a Burr arch-truss at first glance, it is not a comparable design, and it does not function the same way. Although they support a common floor, the multiple kingpost trusses and arches essentially act independently of one another. Under load, both dead and live, each flexes and deforms differently until reaching some deflection combination that shares the load.

An unorthodox design from the beginning, with chords that are neither continuous nor fully independent at the center pier, the way the arches were later added to support portions of the floor with no direct connections to the trusses makes a straightforward analysis of this bridge extremely difficult to do with any confidence. Add the widely varying nature of the wedged connections between the posts and lower chords, along with the addition of the distribution beams under the floor and metal rods parallel to the posts, and the analytical problem becomes one that would, at best, yield only an approximate solution based on numerous assumptions about joint performance and load sharing between parallel members. Accordingly, attempts to quantitatively analyze the bridge's performance during this project were thoroughly frustrated.

It may not be fully understood, but the Taftsville Bridge, unusual as it is, soldiers on into the 21st century. It remains a dependable and distinctive local landmark and a rare representative of a folk tradition in bridge building that will likely continue to serve for many years to come.

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