Bellows Falls Arch Bridge
Spanning the Connecticut River
North Walpole
Cheshire County
New Hampshire

HAER NH-6

PHOTOGRAPHS

Historic American Engineering Record
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Location:	Across the Connecticut River between Bellows Falls, Vermont and North Walpole, New Hampshire. UTM: 18.707500.4779050 QUAD: Bellows Falls
Date of Construction:	1905, altered in 1936
Present Owner:	New Hampshire Department of Public Works and Highways and Vermont Department of Highways.
Present Use:	The bridge carries pedestrian traffic across the Connecticut River. It was closed to vehicular traffic in 1971.
Significance:	When built, the Arch Bridge was the longest single span highway bridge in the United States and it was among the largest three-hinged arch bridges in the world. The structure has also played an important role in socio-economic development of the Bellows Falls and North Walpole.
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Upon its completion in 1905 the Bellows Falls Arch Bridge was America's longest single span highway bridge and the longest arch bridge completely within the United States[1]. Consisting of a 540-foot main arch span over the Connecticut River and a 104-foot auxiliary truss span over the tracks of the Rutland Railroad, the bridge provided a toll-free connection between North Walpole, New Hampshire and Bellows Falls, Vermont that played an important role in the development of the two towns.

In both a technological context and a local socio-economic context, the bridge is historically significant. This report summarizes the construction and operational history of the structure and provides insight into the circumstances which led to the selection of a long-span arch for the site. This is not intended to be the final word on the history of the Bellows Falls Arch Bridge, instead it is intended to provide a foundation for further research. The majority of the research undertaken for this report was sponsored by the Society for Industrial Archeology as part of its study on the possibilities of rehabilitating the bridge. Final preparation of this report, as well as preparation of measured drawings and large format photographs, was funded by the New Hampshire Department of Public Works and Highways as part of its project to replace the Arch Bridge.

In the late nineteenth century, Bellows Falls expanded into an industrial and transportation center. The organization of the Fall Mountain Paper Company in 1872 and the concurrent growth of the Boston and Maine railroad complex in Bellows Falls created a need for additional housing. This fostered development of working class neighborhoods at the northern end of Bellows Falls as well as in Walpole, directly across the river. In 1872, three local men purchased a parcel of land between the Connecticut River and the Boston and Maine Railroad tracks in North Walpole and developed it into a small residential neighborhood.[2] These houses were primarily occupied by railroad employees who worked across the river but, prior to construction of the Arch Bridge, the only access across the river was provided by the Tucker Toll Bridge or the Sullivan Railroad Bridge. Objections of residents and merchants to the toll and the Boston and Maine Railroad's dislike for unauthorized pedestrian use of the Sullivan Bridge eventually stimulated support for another bridge.

Responding to the need for a new economic and social link, both communities adopted resolutions favoring erection of a new bridge at their town meetings in March 1904.[3] Walpole allocated $30,000 for the project, promoting it as an important endeavor which would stimulate population growth and bolster the local economy. Rockingham, Vermont, which encompasses Bellows Falls, adopted a similar motion, and provided $15,000 for the bridge. The towns subsequently established a permanent agreement concerning maintenance costs with two-thirds to be paid by Walpole, one-third by Rockingham. A bridge committee, consisting of five members from each town, was appointed and charged with the responsibility of procuring an appropriate design and contracting the construction of a new bridge.

Following the March town meetings, the Bridge Committee announced a competition for the bridge design. The Bellows Falls Canal Company, who owned and operated a power canal just south of the proposed location, strongly objected to any abutments obstructing the river near their canal. This objection severely restricted the possibilities. Between North Walpole and Bellows Falls the river

is approximately 25 feet deep with no firm foundation for a central pier. In combination, these conditions mandated a single-span structure. The committee received numerous proposals for deck trusses and suspension bridges, but all were rejected because they were too expensive.[4]

Finding no feasible solution on their own, the Bridge Committee requested assistance from the Boston and Maine Railroad. The Railroad had an interest in the project because it wanted to stop pedestrians from using the Sullivan Bridge; thus it offered the services of Mr. Snow, a company engineer, to serve as advisor to the local committee. Familiar with the site because the Boston and Maine owned other bridges in Bellows Falls, Snow believed that a bridge could be built within the budget restrictions. On his recommendation, the Bridge Committee hired J.R. Worcester, a civil engineer from Boston.[5]

Worcester conceived the final design as a 540-foot long three-hinged arch with a suspended roadway spanning the river, coupled with a 104'-8" bowstring truss over the bank at the Vermont end. No long-span structures of this type existed in the United States, but similar bridges had been built in Europe and these may have provided a source for the final design. A slight difference in elevation between the river banks required the roadway deck to have a 3.3% grade sloping upward toward Vermont. The roadway was 32 feet wide with a total length just under 650 feet. The deck was made of Georgia Yellow Pine timbers with a designated load capacity of 100 pounds per square foot.[6]

The bridge consists of two steel arches that are formed by trusses with parabolic chords. Each arch was designed to handle a live load of 60 pounds per square foot placed on the deck. The steel members conformed to the American Railway and Maintenance of Way Association standards which required them to have tensile strength of 60,000 pounds per square inch. Forged steel hangers, 1-1/4 inches square, were used to suspend the deck from the arches. The hangers were only designed to support the vertical load of the deck and traffic. Lateral bracing was incorporated into the deck and between the trusses to provide resistance against horizontal wind stresses. The total weight of the structural steel in the bridge amounted to 450 tons.[7]

In what may have been an effort to make the bridge more aesthetically pleasing, Worcester did not allow the top and bottom chords of the arch to converge at the top of the span as they would in a conventional three-hinged design. Instead, Worcester replaced the center hinge in each arch with a compression joint by inserting a horizontal strut between the chords and connecting it to the chords by diagonal steel members. Through this design feature the compressive stresses were transferred through the joints to the trusses comprising the arches and, consequently, the outline of the top and bottom chords of the arches appeared continous throughout their entire length.[8] Worcester evidently appreciated the visual effect created by this connection since he wrote in a letter to Thomas Bellows Peck, a member ofthe Bridge Committee, "Whatever beauty it [the bridge] may possess is due to the fact that construction lines are satisfying to the eye."[9]

Construction of the bridge began in November 1904. The first task was the erection of four wooden towers to serve as falsework. This was performed by Joseph A. Ross and Sons, a Boston contracting firm which was hired to drive the piles for the falsework and build the masonry abutments. In keeping with the economy of the project, the supporting piles were spruce, later sold to the local pulp mill. Beginning in December 1904, the main arch superstructure was assembled from prefabricated steel sections by Louis A. Shoemaker and Company of Philadelpia. With construction crews working from both sides, the trusses were cantilevered toward the center of the river. Each connection was temporarily bolted together rather than riveted so that adjustments could be made if the two halves of the arch did not meet properly. A rivalry between the two team of workers developed, and this probably helped to speed up the assembly process. The trusses were connected on January 10, 1905, after only twenty-eight working days.[10]

The bridge was completed with assembly of the deck and the permanent fastening of all the connections. Installation of the hanger rods and deck supports occurred simultaneously with the contruction of the cross bracing that connects the two arches. The final procedure involved the riveting of all the steel members together and was intended to be done with a pneumatic riveter. However, a fire in the tool shed the day before the process was to begin destroyed the compressor, and, consequently, all the riveting was performed by hand. Total construction time for the bridge was 4 months, and a total of forty-five men were employed.[11]

Formal opening ceremonies were held on March 20, 1905. The event was hailed as a great day for North Walpole and Bellows Falls since residents now had a convenient alternative to the Tucker Toll Bridge. For more than twenty years the structure carried traffic without major incident until, in 1927, the Connecticut River overflowed its banks and the New Hampshire end of the bridge was inundated with water. The damage was not great, however, and the bridge was soon back in operation.[12]

On March 19, 1936, the Arch Bridge suffered extensive damage when a major ice jam on the river broke apart and sent large blocks of ice floating downstream. These ice blocks struck both ends of the upstream side of the bridge and bent some of the lower steelwork. The impact left the structure leaning slightly upstream. It was at this time that the horizontal bracing between the arches helped prevent complete collapse. Needing major structural repair, the bridge was closed. A great debate arose over rebuilding or replacing the Arch Bridge. Since the steel had been well maintained, reconstruction was deemed the best alternative.

Reconstructing the Arch Bridge equalled the task of initial construction. The operation necessitated raising the entire structure through a complex jacking procedure, and placing it on specially designed falsework. Wire bridge cables were fastened to the ends of each arch to resist the horizontal thrust once the bridge had been detached from the abutments.

Actual repair resulted in removing the damaged steelwork from both ends, thus shortening the length of the trusses. New steel beams were then attached to the ends of each chord and connected to new hinges. To compensate for the decreased length, the abutments that supported the hinges had to be re-designed and enlarged. With the new components in place, the arch was lowered into position and re-aligned. During reconstruction, the original timber decking was removed, and a new 3-inch thick steel grid deck, infilled with concrete, was installed. To insure that similar damage would not occur again, the steelwork below the hinges was encase in reinforced concrete. The end result of the repair effort was a structure essentially identical to the original bridge design except that the span was decreased by 54 feet.[13] The complicated procedures described above were carrried out during November and December 1936. The American Bridge Company of Philadelphia performed the operations under contract with the New Hampshire Highway Department. The total cost of the repairs amounted to $120,000, a sum substantially less than would have been needed for a new structure.[14]

In 1961, the secondary bowstring truss over the railroad tracks on the Vermont side of the bridge was removed. Rockingham erected an I-beam girder bridge in its place. At the same time, a thin layer of asphalt was applied to the road surface. In 1971, the State of New Hampshire became concerned about the bridge's structural condition and hired a private consulting firm to inspect the structure. This evaluation indicated that the bridge was not in a condition warranting its continued operation and the structure was closed to vehicular traffic.

FOOTNOTES

1. Henry G. Tyrell, History of Bridge Engineering (Chicago: The G.B. Williams Company, 1911), p. 349.

2. Martha M. Frizzel, A History of Walpole, New Hampshire, vol. I (Walpole Historical Society, 1963), p. 406.

3. L.D. Rights, "Erection of the Bellows Falls Arch Bridge," Papers and Discussions, vol. 34, n. 3 (American Society of Civil Engineers, March 1908), p. 204.

4. ibid, p. 204. The Bellows Falls canal was begun in 1927, opening as a navigation facility in 1802. Later converted to a power canal, it is now used to supply water to a hydro-electric generating station. Beginning just south of the Arch Bridge, the canal circumvents the falls of the Connecticut River and terminates just below the Vilas Bridge. It forms a border between the industrial district and the downtown area of Bellows Falls. Integral to transporting lumber in the early nineteenth century, it was also tapped for power during that period. By 1858, the railroad supplanted the transportation functions of the canal, forcing it to be closed. Afterward, it served only as a power canal and was owned by the Bellows Falls Canal Company. When the proposals for building a bridge were initiated in 1904, it was the Canal Company that raised objections to placing an abutment in the river that would obstruct the flow of water. In this sense, the canal, mandating a single-span structure, led to the design of the Arch Bridge.

5. ibid, p. 204.

6. ibid, p. 204-206.

7. ibid, pp. 205-206.

8. ibid, p. 207.

9. Preliminary Case Report, The Arch Bridge (Concord, NH: New Hampshire Department of Public Works and Highways, 1976), p.22.

10. Rights, p. 210.

11. ibid, p. 210.

12. Frizzel, p. 522.

13. N.E. Langley and Edward J. Ducey, "Reconstruction of the Walpole-Bellows Falls Arch Bridge," Proceedings (American Society of Civil Engineers, April 1939), p. 680.

14. Langley and Ducey, p. 1675.