Historic Structures

significant structures of the past

Piscataqua Bridge

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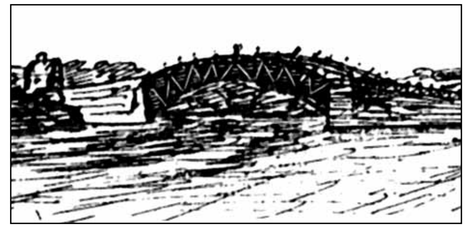
The Piscataqua Bridge across the Great Bay of the Piscataqua River is located six miles west of Portsmouth, New Hampshire, and was built in 1794 with a span of 244 feet. It was the longest span bridge in the United States when it opened, holding that record until Lewis Wernwag built his Colossus Bridge across the Schuylkill River north of Philadelphia in 1812 with a span of 340 feet. Timothy Palmer had built bridges across the Merrimack River in Massachusetts, and was a pioneer in long span wooden truss bridge design and construction when he was called to build the most difficult part of the Piscataqua Bridge.

Palmer's first bridge was the Essex–Merrimack Bridge, west of Newburyport across the Merrimack River, that opened in 1792 (*June 2013 issue of STRUCTURE magazine*). That bridge was followed by a bridge at Andover (now Lawrence) Massachusetts across the same river in 1793. The bridge was built "to open a communication between Portsmouth and the interior of the state, and to divert its trade from Boston, Newburyport, and Portland, by which it has hitherto been engrossed. This bridge lies in a direct course to the heart of the state; and a turnpike road was originally intended to be opened from it to Concord on the Merrimack, and thence to the Connecticut River."

The Turnpike had been started in 1791 to connect Concord, the capital, with tidewater at Durham, New Hampshire. The users of the turnpike found, however, that a direct land route to tidewater at Portsmouth would be most advantageous and urged the construction of a bridge across the Great Bay connecting Durham with Newington.

The initial petition to the legislature was submitted in December 1792 for authorization to build a toll bridge, and a survey made of the crossing and the results were published in the Portsmouth Herald on June 4, 1793 as follows:

From Fox point to Ram Island, 600 feet at high water, depth from 50 to 54 feet.
From Ram island to Goat Island, 330 feet at high water, depth from 42 to 44 feet.
From Goat island to Tuttle point on Durham side, 888 feet at high water, depth from 42 to 44 feet.
Length on the water 1818 feet.
Breadth Ram island 50 feet.
Breadth Goat island 390 feet.
Whole length of bridge 2258 feet.



The existence of Goat Island in the middle of the Bay cut down on the amount of bridging required. In addition, a roadway system of sorts was in place as Furber's Ferry was in service across the Bay.

The state legislature granted a charter for the bridge to the Proprietors of Piscataqua Bridge on June 20, 1793 for an "Act to incorporate certain persons for the purpose of building a bridge over Piscataqua River between Bloody Point and Furber's Ferry so called and for supporting the same." The act also indicated that "a draw or Hoist, over some one of the channels shall be constructed of such width as the Judges of the Supreme Court of Judicature shall direct, previous to the erection of said Bridge, not exceeding forty feet, so that vessels may freely pass and repass through the same.

Shortly after receiving the charter, the Proprietors began purchasing the property at both ends of the bridge and Palmer was formally selected in mid 1793. He gave them the design for the long trussed span; they started ordering materials for the bridge in November 1793 based upon his design. Major Zenas Whiting of Norwich, Connecticut was selected to build the trestle approach structures and the required draw span. The Whiting Bridge was a trestle structure on each end at the sides of the river and the Great Arch, Palmers 244-foot span, was over the main channel. The trestle's were "…supported by piles, five of which were strongly framed and braced together and driven into the bottom of the river bed; string pieces were laid from one set of piles to another, and on them the planks or flooring was secured." On the Durham side, Whiting built a small draw span for high masted boats.

Notices in the *New Hampshire Gazette* on November 30 and December 11 described the wood that the Proprietors would need to build the entire bridge, including the long arch. Since the plans are missing and presumed lost in the fire at the offices of the bridge company, the materials ordered taken in conjunction with other Palmer Bridges give an idea of the size and placement of his members in the bridge. Robert Gilmor, who visited the bridge in 1797, made a sketch of Palmer's prominently featured arch.

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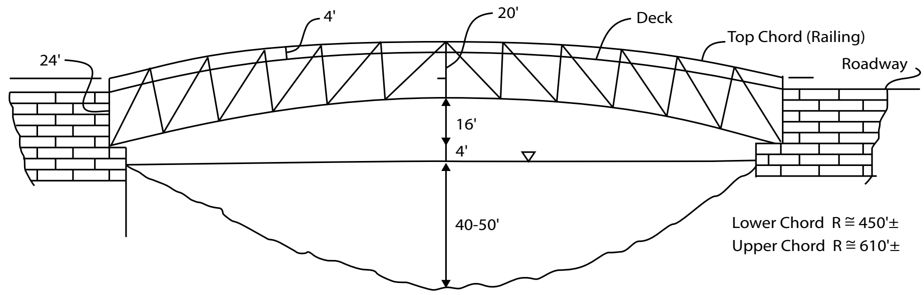
The December 14, 1793 issue of the *New Hampshire Gazette* listed the timber required for the arches. It included 1,535 pieces of pine timber from 15 feet to 50 feet in length, and ranging in size from 3 inches by 5 inches to 14 inches by 18 inches. Ninety-four of these pine timbers, intended for use in the wooden arch of the bridge, were to be 50 feet long and 14 inches x 18 inches with a 20-inch curve or sweep over the 50 feet. In other words he, wanted 50-foot long 14 x 18 pine timbers with a natural bend in them.



Palmer designed his "great arch" with three sets of arches over a total width of 38 feet; each of these arches were different than his previous bridges as he added a third intermediate member of the structure to carry the floor, rather than resting the floor on the bottom chord. In the words of a local historian, "the arch is composed of three tiers of girders, the lower one is sixteen feet from the chord, and twenty feet from the water at high tide. The second tier supports the planking on which the road passes, which is on a larger circle to facilitate the travelling. The upper tier answers the purpose of railing. There are three sets of these girders, one on each side, and one in the middle of the bridge, which are so braced and framed together, as to make them whole strong and firm." In other words, the lower arch was the bottom chord of his truss, the upper arch was the top chord of his arch and the middle arch carried the floor to the truss. The span was almost 30% longer than his longest previous bridge.

As with most wooden bridges of the time, the timbers would be cut and drilled to plan and erected off site to assure the proper fit of all members. The trusses would then be dismantled and transported to the bridge site and re-erected on falsework. After all the connections were finished, the falsework would be dropped and the truss/arch would stand-alone.

Work started on April 1, 1794 and the bridge was completed on November 25 of the same year. Palmer built massive falsework on which to build his trusses in the 50-foot deep and rapidly moving water. From a constructability standpoint, the falsework must have been as difficult to erect as the bridge. The main reason, other than depth of the water, was the 7-8 foot tidal range in the Bay. Palmer would later state, "he had, at the Piscataway Bridge, erected an arch of 244 feet; but he repeatedly declared that, whatever might be suggested by theorists, he would not advise, nor would he ever again attempt extending an arch, even to our distance, (Permanent Bridge) where such heavy transportation was constant proceeding."

The December 9, 1794 issue of the *Portsmouth Gazette* gave information on the bridge; its length was given as 2,362 feet, and width 38 feet. The article described the trestles as being built "on piles from fifty-three to sixty-five feet, driven into the bed of the river by 'large hammers' of oak timbers, braced and framed on a new and improved plan." The bridge construction used 3,000 tons of oak timber, 2,000 tons of pine, 80,000 feet of 4-inch plank; 20 tons of iron; and 8,000 tons of stone. Enos Whiting of Norwich, Connecticut is credited with superintending the pile work, and also with constructing "a draw for the passage of shipping, which moves across in a horizontal direction, instead of being raised on hinges, but it is feared this expected improvement will not answer the purpose."

Adams wrote "hundreds of people came long distances to cross and view the great enterprise that so auspiciously opened a new era in business. The Architect was Timothy Palmer of Newburyport, and the success of his work earned for him a great reputation. The entire bridge, [including the trestle spans and draw spans] cost $65,974.34, a large sum for those days."

It is clear that Palmer's top chord on this bridge was only at railing height, and that the deck was close to the top chord and some distance (16 feet) above the bottom chord. This was the first time he changed his normal method of bracing the top chords overhead. He determined that a deeper truss was required for the longer span and that it became more difficult to have overhead cross braces, even if connected with ships knees, to provide sufficient lateral bracing. By having the deck near the top chord, it is possible to cross brace the trusses below the deck down to the lower chord.

The bridge sparked a great deal of interest in the few international journals and books dealing with engineering subjects in the late 18th and early 19th century. The first written description of the bridge was in the *Dictionary of Arts, Sciences and Miscellaneous Literature* in its Supplement printed in Philadelphia in 1803:

> *…a wooden bridge erected in North America, in which this simple notion of Grubenhamm's is mightily improved. The span of the arch was said to exceed 250 feet, and its rise exceedingly small. The description we got is very general, but sufficient, we think, to make it perfectly intelligible. In… are supposed to be three beams of the arch. They consist of logs of timber of small lengths, supposed of 10 or 12 feet, such as can be found of a curvature suited to its place in the arch without trimming it across the grain. Each beam is double, consisting of two logs applied to each other side to side, and breaking joint, as the workmen term it. They are kept together by wedges and keys driven through them at short intervals…*

Thomas Pope, in his 1811 *A Treatise on Bridge Architecture*, wrote that the "part which engages the attention of travelers is an arc nearly in the centre of the river, uniting two islands, over water forty-six feet deep. This stupendous arc of two hundred and forty-four feet on the chord, is allowed to be a masterly piece of architecture, planned and built by the ingenious Mr. Timothy Palmer of Newburyport…"

Since the original plans for the bridge have been lost in a fire at the company offices in Portsmouth, it is necessary to rely on the observations of travelers, and later writers, who were not engineers or builders but who had actually seen the bridge and crossed it, to understand the design and construction of the bridge and the impact it had on users.

Timothy Dwight crossed the bridge in the fall of 1795, and described it as follows:

> *…This structure stands in a region which gives it every advantage to make a striking impression on the mind…we came suddenly upon the bridge, an enormous structure, twenty-six hundred feet in length, of an interesting figure, finished with great beauty and elegance, new, white, and brilliant. There are at this place two islands in the river; one, next to the southern shore, an oblong narrow rock: the other of sufficient extent for the site of house, garden, and some other enclosure…The whole scene had the appearance of enchantment, and in Arabia might not unnaturally have been attributed to the hand of a genie...Piscataqua bridge is formed of three sections; two of them horizontally, the third arched…The arch like the Haverhill Bridge [built in the following year] is triple, but no part of the work is overhead. The chord is 244 feet; and the versed sine, nine feet and ten inches. This arch is the largest in the United States, contains more than seventy tons of timber, and was framed with such exactness that not a single stick was taken out after it had been once put in its place. The whole length of planking is 2,244 feet. The abutments make up the remaining 356 feet and the island already mentioned…This is by far the most interesting structure of the kind which I have ever seen. Like the face in a well-contrived portrait, it is surrounded by such objects as leave the eye to rest on the principal one, and the mind to see but a single impression.*

Fletcher and Snow described the bridge as follows:

> *Its length was 244 feet, the rise was 27 feet 4 inches and the depth of framework of the arch, 18 feet 3 inches. There were three concentric ribs the middle one carrying the floor of the bridge. The ribs were made from crooked timbers, so that the fibers were nearly in the direction of the curves, and they were connected by pieces of hard and incompressible wood, with wedges, driven between. The ribs were mortised to receive these connecting pieces and wedges, thus keeping an equal and parallel distance between them. Each rib was formed of two pieces, about 15 feet long, laid side by side in such a manner as to break joints. Their ends all abutted with square joints against each other, and were neither scarfed nor mortised. The two pieces of timber being held together by transverse keys and joints. All the timbers were admirably jointed and freely exposed to the action of the air. Any piece might be removed for replacement without injury to the remainder of the structure.*

It, primarily the deck portion, was rebuilt in 1803 when a lottery was held to cover the reconstruction. It was unusual that a wooden bridge would have to be rebuilt in only 7 years, but exisiting uncovered in a New Hampshire coastal environment could have accounted for significant decay of some of its members. The tolls were not sufficient to cover expenses, and the bridge was never a financial success.

In 1818, Cyrus Frink, who had completed most of the earlier repairs, replaced the arch with "an entire new bridge, according to a wooden plan by him exhibited to the directors." The reconstruction, including the new arch, was to be completed between June 4th and September 15th without obstructing or impeding the passengers. What his plan was, and how he replaced the main span while not cutting off traffic, is not clear. Whatever he did, it resulted in the removal of Palmer's span.

Frink's bridge gave way on March 18, 1830 and, after being rebuilt, gave way again in 1854 and was not repaired. An ice jam on February 18, 1855 took the remainder of the bridge out. By that time, traffic had decreased significantly due to competition from the railroad that had opened between Boston and Portland, Maine, and the bridge was not rebuilt.

This bridge was the most written about of any bridge in the country until Palmer's Schuylkill River Permanent Bridge in 1805. Its 244-foot span was 84 feet longer in span than the Newburyport Bridge and incorporated an entirely unique framing plan, one that he, in part, was to use in his later bridges across the Schuylkill and Delaware Rivers.▪