Blair Bridge, Campton, NH
Covered Bridge Project Report

Phase 1 - Research and Inspection Findings

Prepared by Historic Documentation Company, Inc., Portsmouth, RI, November 2009

Summary History and Significance

Blair Bridge was built in 1870 by Hiram W. Merrill, a carpenter and wooden bridge builder from Plymouth, New Hampshire. It replaced the covered bridge built on the site in 1829 that was destroyed by fire in 1868. The new bridge was built on the existing pier and stone abutments that supported the first bridge and was of the same type, based on the design patented by Col. Stephen H. Long in 1830. Long (1784-1864) was a native of Hopkinton, New Hampshire. He was an Army engineer and one of America's leading western explorers and early railroad engineers. He is considered America's first structural engineer for the truss design he patented, of which Blair bridge is both an authentically reproduced and exceptionally well-preserved example. The Long truss was the first truss bridge type used by the railroads in the United States (1831-1832) and is considered to be the first scientifically designed truss bridge and the first example of an intentionally prestressed bridge. The Blair Bridge is the only surviving example of a Long truss in New Hampshire utilizing Long's patent prestressing method and is one of the longest and best preserved examples in the United States.

The original contract between Merrill and the town and other documents pertaining to the construction of the bridge are held in the Campton Historical Society (CHS) collection. Merrill was paid $1200 for the labor to construct the bridge. The town paid directly for all of the materials which totaled approximately $2500.00. The terms called for Merrill to begin work on May 1, 1870 and to complete the bridge by July 15, ten weeks later. It does not appear that the bridge was completed on schedule: Merrill was paid $1,180.00 on October 20, 1870, and the balance of $20.00 the following April. According to Campton Town Annual Reports (Town reports) numerous repairs have been made to the bridge over the years. In 1977 extensive repairs were made to the bridge by Milton S. Graton, a well-known covered bridge contractor. Repairs are discussed in the inspection findings section below. A detailed history and historical context of the bridge has been prepared by NH State Architectural Historian James Garvin in the form of a NHDHR Individual Inventory Form to which the reader is referred for additional historical information.

Research Findings

Research for primary and secondary source information was conducted at the Campton Historical Society (CHS), New Hampshire Division of Historical Resources (NHDHR), the NH State Library and the NH Historical Society. A search for published literature was conducted at University of Massachusetts at Dartmouth utilizing several technical journal databases including Engineering Index Backfile which catalogs all engineering articles since about 1884. The original Col. Stephen Long bridge patents and writings were obtained from Library of Congress microfilm held by University of Rhode Island and Roger Williams University (RI). A bibliography of documentary materials gathered to date and used in the preparation of this report is attached.

Inspection Findings

The bridge was inspected on 24, 25 September 2009 in conjunction with the Hoyle-Tanner (HTA) engineering inspection team. HTA and Wright Construction Company provided ladders and rolling scaffolding to facilitate access. Digital photographs of the interior and exterior of the bridge were taken.

Trusses and Overhead Framing

The Long truss has parallel upper and lower chords, or "strings" as Long referred to them, built up with three parallel members bolted together side by side. The paired vertical posts are in tension and the diagonal cross braces (two main braces and one counter brace) are in compression. Wood wedges are inserted at the foot of the counter braces which allowed the builder to adjust the shape of the panels, the initial camber, and to induce forced loads (prestressing) in the diagonals. A laminated wood arch, located inside the trusses and up against them, was added to the structure sometime after its construction, apparently in 1875 (see Photo No. 1). The arch is further discussed below.

Essentially all of the timber of the bridge with the exception of the floor system and the obvious repairs done in 1977, appear to be original. All of the wood shows circular saw marks as would be expected on lumber sawn in 1870. The wood appears to be of the same species, probably white pine or hemlock. According to the Town report for 1870 two payments were made for lumber for Blair bridge: "Paid on lumber for Blair bridge, $800.00" and "A.H. Cook, for lumber for Blair bridge, in part, $960.00."

In 1977 Milton Graton of Graton Associates "completely rebuilt the four corners of the bridge." Photos in his book show some of the work; one photo caption reads "new bottom chords and vertical post splices were installed" (see Photo No. 2). It is assumed that the chord members referred to were at the ends of the bridge; it is not known if he replaced others at mid span or at the ends over the pier. The engineering inspection revealed severely deteriorated chords members at the ends over the piers.

The rafters are spaced ten feet apart and rest on the cross beams which in turn rest on the upper chords. The cross beams are butted against the ends of the posts with extend about 12" above the cords. As mentioned above, the rafters are attached to the cross beams at their ends with iron dogs as well as two nailed-on struts. The 4" square purlins are spaced approximately 16" on centers (see Photo No. 3).

Iron Fasteners

Iron bolts, dogs and spikes are used throughout the bridge to join the members, all of which appears original to the bridge except those used in conjunction with obvious repairs. The Town reports for 1870 and 1871 list several payments for iron bolts, nails and "iron work" for Blair Bridge. The chord members are thru-bolted to the posts and also bolted together through shear-blocks and spacers at two points between posts. The cross beams that join the two trusses at the top of each post (panel point) are bolted to the inside top chord member with vertical thru-bolts. The truss diagonals (main brace and counter-brace) are bolted together at their intersection points. This is consistent with Long's *Instructions to Bridge Builders* (1836) in which he describes the use of bolted connections "to advantage" in the construction of his bridge design.

Three types of threaded bolts were observed all of which appear original to the bridge: (a) round bolt with square head, ogee washers and square nut; (b) square rod with two-part head (upset end holds square washer with square hole), threaded end with square washer and nut; (c) round bolt threaded both ends with ogee or square washers and square nuts (see Photo No. 4).

The rafters are joined to the cross beams with cramp irons or dogs consisting of round rod with bent and sharpened ends driven into the timbers (see Photo No. 3). The diagonal wind or knee braces that join the posts to the upper cross beams are attached with rounded-headed spikes. Spikes and nails were also used to attach the purlins to the rafters, the siding and for other connections.

Floor System

In his book Graton states "nearly all the floor joists were replaced in the laying of the new 4 inch plank floor." Numerous entries in the town reports over the years mention "lumber for Blair bridge" and "labor on Blair Bridge" or "repairs to Blair Bridge" and it can be assumed that in several cases these entries refer to flooring replacement. The floor beams (Graton calls them joists) that were replaced by Graton in 1977 were all (or nearly all) located between the posts. The floor beams at the posts were apparently left in place due to the difficulty in replacing them because the diagonal counter braces are wedged against them. Between the posts, at many locations, the original 6x12" beams were replaced with 4x12 beams, perhaps on closer spacing than the original beams. In some cases, old beams with sufficient strength remaining were turned upside down to provide a fresh nailing surface for the decking. In other cases new beams were sistered to the old beams (see Photo No. 5 and No. 6).

Arches

The original contract called for "Said bridge to be built on the model of said Blair bridge – the same having been one of Long's Patent timber bridges so called – except that there are to be no arches unless the town shall so elect reasonably and where the town is to pay eighty dollars extra beyond the consideration hereinafter named." Physical and documentary evidence strongly suggests that the arches were constructed by a different builder and added after the bridge was completed. There is no record in the town reports of any additional payments to Merrill beyond the $1200.00 specified in the contract. The 1876 town reports list payments of $518.41 to Ruins Foster for "repairing Blair bridge" and $203.31 to Benjamin Sweet for "Lumber for Blair bridge." These expenditures probably represent the construction of the arches.

Physical evidence that the arches were added includes notching of the truss members, alteration of the original knee braces and the drilling of the lower chord member splice blocks to accommodate the iron hangar rods. The longer, secondary knee braces appear to have been added after the arches to provide additional stiffness to the structure. In his *Directions to Bridge Builders* (1836), Long states that "Care should be taken in the insertion of bolts, &c. that they be introduced only where the strength and efficiency of the timber is not likely to be impaired by them." The random placement of the hangars, their unconventional attachment directly to the chords instead of to needle beams, and manner in which they were angled and bent around timber members exhibits haphazard workmanship incongruent with that exhibited by the truss and other portions of the structure (see Photo No 7 and No 8). It was unanimously concluded that the builder of the truss and the builder of the arch could not be the same person. The wood blocks at the bottom of the hangars that support the chords are not uniformly sized and were not secured (nailed) in position crosswise to the chords to bear uniformly. Most support blocks are at random angles suggesting they have rotated due to vibration and being loose.

Siding and Roofing

The original contract between the Town of Campton and Merrill called for "The sides are to be boarded up thirteen feet from the lower chord – the remaining space to the upper chord being left open. The roof to be covered with long shingles and the frame to be made according to the schedule of lumber furnished by A. H. Cook."

Graton replaced the siding in its entirety in 1977. Many entries in the Campton reports mention wood or planking and repairs for Blair Bridge but do not mention the siding specifically. If it was regularly oiled or painted then the deteriorated siding removed by Graton may have been the original. If it was not maintained, then it was likely replaced wholly or in part one or more times over the lifetime of the bridge. Graton apparently added the present window openings. Photos of the bridge taken prior to the 1977 work (in Graton's book and in the CHS collection) show the siding as originally specified: solid vertical planks that stop 3 feet below the top chord to provide a continuous opening under the eaves the entire length of the bridge. The roof was given a wide overhang to shade the timbers exposed by the wall opening and keep out rain except for the occasional wind-driven rainstorm.

The original wood shingle roof was replaced with a metal roof in 1913 when extensive repairs were also made to the substructure. The roofing was supplied by Penn Metal Company and cost $342.95 plus $7.80 for freight. Four men were paid for "labor on Blair Bridge" in varying amounts that totaled $42.13. Graton again replaced the metal roof in 1975.

Substructure

The stone abutments and piers have been investigated by a masonry contractor that specializes in historic stone masonry so specific details of their construction and condition are not discussed here. From the historic preservation standpoint, the stone substructures are *character defining features* that contribute to the National Register eligibility of the bridge. Although the historic integrity of the stonework has been diminished by incompatible repair work, by damage from fire, and by environmental degradation, it retains sufficient integrity to convey the historic materials and methods of its construction and therefore any proposed repairs or treatments must comply with accepted preservation practice.

Conclusions and Recommendations

The advantage of Long's design was that it utilized small quarter-sawn timbers, simply joined. Chords were intended to be spliced, all other members were not. Failed or deteriorated structural members should be fully replaced with new identical reproductions and hot branded with the year of replacement. Splicing or sistering of structural members should be done only when justified by special circumstances. The iron fasteners identified as original to the bridge are character defining features and should be retained where ever possible.

The repairs made in 1977 are for the most part are incompatible with the original design and materials of the bridge and can be replaced if recommended by the engineering study. The splices used to repair the posts at the end corners of the bridge were an economical solution but are inconsistent with Long's design intent and create a false sense of importance and history that distracts from the proper interpretation of the structure.

The arches, although not an original feature of the Long truss design, contribute to the esthetic and historic interest of the bridge. They should be retained providing it can be shown by the engineering study that they are not detrimental to the structural stability and life of the trusses.

The new window openings are leading to accelerated weathering deterioration of the exposed timbers and should be eliminated entirely. At the minimum the windows should be greatly reduced in size and repositioned between the truss members so the members are not directly exposed to weather. Members below new window openings or otherwise subject to wetting should be waterproofed and the floor equipped with a means of drainage.

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Photo No. 1: Interior view of bridge. View W.


Photo No. 2: Post repair at SE corner done in 1977 showing bolted splices and shear dowels. View S.


Photo No. 3: Top chord of south truss (right); top of arch (bottom); cross beam (center) showing wedges against lateral brace (left); rafter attached to tie beam with cramp iron or "dog." View SE.


Photo No. 4: Top chord members showing square rod tie-bolts with upset heads and square washers. View SW.

Photo No. 5: East abutment and underside of bridge, showing 1977 concrete reinforcement, and assortment of floor system repairs and problems; note deteriorated floor beams at top of photo. View E.

Photo No. 6: Underside of east span, showing floorbeams, triple lower chords and arch hangar rod support blocks. View up.

Photo No. 7: South truss and arch of west span. View south.

Photo No. 8: Detail of arch, north truss, west span, showing angled and bent hangar rods. View NW.