HISTORIC AMERICAN ENGINEERING RECORD/ NEW HAMPSHIRE HISTORIC PROPERTY DOCUMENTATION

CHESHIRE RAILROAD STONE ARCH BRIDGE

NH State No. 641

LOCATION: Former Cheshire Railroad/Boston & Maine Railroad Right-of-Way spanning The Branch River, Cheshire County, Keene, New Hampshire.
USGS Marlborough, New Hampshire, Quadrangle
UTM Coordinates: 18.724194.4754712

BUILDER: Cheshire Railroad Company

ENGINEERS: Lucian Tilton, William S. Whitwell, Cheshire Railroad Company

DATE: 1847

PRESENT OWNER: State of New Hampshire

PRESENT USE: Recreational trail bridge

SIGNIFICANCE: The Cheshire Railroad was significant to the development of the city of Keene and Cheshire County New Hampshire, and an important link in the railroad transportation network of New England for over 100 years. The Cheshire Railroad surpassed all other rail lines in New Hampshire in its mastery of masonry construction and in the bold use of the stone arch for its many stream crossings. The Cheshire Railroad Stone Arch Bridge is among the most important masonry arch bridges constructed in the United States before 1850. It is the largest of twenty impressive stone arch bridges and culverts built under the supervision of Chief Engineers William S. Whitwell and Lucian Tilton, for the Cheshire Railroad. Whitwell and Tilton were accomplished engineers and founders of their profession in the United States.

PROJECT INFORMATION: Cheshire Railroad Stone Arch Bridge was documented in accordance with the standards of the Historic American Engineering Record in the summer of 2009 by Historic Documentation Company Inc. (HDC), Portsmouth, RI, for CHA Inc., Albany, NY and the City of Keene. NH. The report was written and compiled by Richard M. Casella, Engineering Historian, HDC. Rob Tucher Photographic Documentation conducted the large-format film photography. Portions of the report are taken from NH Historic Property Inventory Forms prepared by James L. Garvin, NH State Architectural Historian (2006), and by Elizabeth J. Hostutler, NH Department of Transportation (1994). This documentation was undertaken as part of an engineering study of the bridge to identify repair and maintenance requirements.

DESCRIPTION

Setting

The Cheshire Railroad Stone Arch Bridge (Cheshire Railroad Arch) is a single-span, stilted semi-circular arch bridge spanning The Branch River in the area of the City of Keene, New Hampshire, historically known as South Keene. The Branch River is a tributary of the Ashuelot River and is formed by the confluence of Otter Brook and Minnewawa Brook.[1] The bridge is built into a long (~700') and high (~ 45') earth embankment built by the Cheshire Railroad in 1847 to carry the tracks across the river valley in a northwest direction into the center of Keene. The width and height of the bridge required to span the river and the need to protect the bridge approach embankments from erosion with retaining walls, resulted in the massive stone edifice that is the subject of this report.

The immediate area surrounding the bridge is wooded with the exception of a small flood plain area on the upstream (east) side of the bridge bounded by the Route 101 road embankment. The nearest buildings are residential, located about 500 feet from the bridge on the north side of Route 101. Bridges that carried the railroad over Swanzey Factory Road southeast of the bridge and Marlboro Street (Route 101) northeast of the bridge were removed after the last owners, the Boston and Maine Railroad, abandoned the line. The rails and ties have since been removed and the right-of-way now serves as a recreational trail.

Physical description

The arch has a radius of 34'-0" giving it a clear span at the springline of 68'-0" (refer to Figure 1 and Drawings 1-3). The arch proper, meaning the portion above the springline consisting of the tapered ring stones known as voussoirs, rests on three courses of stone 5'-4" high between the springline and the top of the footing, making the total opening 39'-4" from the top of the footing stone to the bottom of the keystone. This type of semi-circular arch with an opening extending below the springline is called a stilted arch. The width of the arch is 27'-1" from face-to-face. The stone coping projects an additional 10" on each side.

Flanking the arch on both sides are buttressed abutments, followed by curved wingwalls and finally wingwall extensions that give the bridge stonework an overall length of 182' end-to-end. The buttresses are 9' wide and project about 20" from the face of the arch. The wingwalls curve outward following a quarter-circle radius to a point approximately 20' from the face of the arch, then turn 90 degrees again and extend 30' in a straight line, parallel to the right of way. The wingwall extensions retain the earth fill of the approach embankments against the abutments.

The river banks upstream and downstream of the wingwalls are armored with large pieces of granite rubble that help protect the walls from scour and ice floes. The color of the scour protection stone is somewhat lighter than the arch and wall stone, suggesting that it was from a different source, such as one of the rock cuts made for the line south near Troy, or that is was placed at a later time, or both.

The northwest wingwall contains a voussoir arch filled-in with cut stone of the same type as the wall. The arch is mostly buried by the earth embankment but the top of the arch is visible and can be estimated to be 18 to 20 feet in width. The earth fill against the other three wingwall extensions rises higher than the elevation of the top of the wingwall arch and therefore it is not known if the other walls have similar arches as well. The exact purpose is not known, but it is most likely a reliving arch, meant to carry the load of the wall above, down to two suitable foundation points built into the bank. The other possibility is that the arch was built to accommodate a road along the river, as was typically done in railroad bridges of this type, but during construction it was decided not to provide it.

Masonry Details

The bridge is built of a fine-grained gray granite that was reportedly quarried within a half-mile of the bridge site on the Thompson Farm in the neighboring town of Roxbury. [2] The Roxbury granite is from the same geologic formation as the famous Concord Granite. It is classified as a two-mica (biotite and muscovite) granite from the Late Devonian geologic period, making it approximately 375 million years old.[3] Concord granite is an excellent building stone and in 1873 the Keene Granite Quarry in Roxbury attained notoriety when it employed 150 quarrymen and 200 stonecutters to fill an order for the construction of the statehouse in Albany, New York.[4]

The arch and wingwalls of the bridge are all built of cut stones, precisely squared and smoothed, and laid in continuous even height courses. This squared stone masonry work is traditionally called "ashlar" and the even coursing is called "range-work." The individual stones – except for the ring stones – measure approximately 18" to 24" in height, 30" to 80" in length, and average 24" in depth, the largest weighing approximately 5000 pounds.

The ring stones, known as voussoirs, are slightly wedge shaped to follow the curve of the arch, measuring 21" ± wide across the top and tapering to 20" ± at the exposed bottom face, known as the soffit face. The voussoirs are 36" ± in height and vary in length from 28" to 60" with the majority measuring between 32" and 48". The keystone projects about 3" out from the other voussoirs.

The courses of stone run continuously across the spandrels, buttresses and wingwalls, and are constructed of the same precisely squared stone. This feature sets the bridge apart from most others that typically incorporate lesser quality masonry for the wingwalls, and often for the abutments (buttresses) and spandrel walls as well.

The facewalls of the bridge and buttresses are capped with a projecting belt course with another course above that set back to the plane of the facewalls. This unusual arrangement is due to the removal of the original parapet in 1903 to permit the clearance between the two parallel tracks to be increased to modern specifications.[5] Two courses of stone plus the top course of projecting cap stones (or coping stones) were removed. An iron or steel pipe railing was installed that has since been removed leaving short stubs of pipe projecting from what is now the top stone course of the parapet.

The faces of the stones are left with the natural rough surface resulting from splitting at the quarry, known in masonry terminology as rough-faced, split-faced or quarry-faced. There is occasional evidence of chisel or hammer strikes on the faces, but an attribute of Concord granite is its uniform bedding planes and clean splitting. Half-round drill holes left from splitting the stone are evident on the edges of many stones and typically measure 3/4" in diameter by 2-1/2" to 3" deep indicating they were made for plug and feather splitting wedges. The only decorative tooling that was done are the 1" wide flat borders chiseled along the edge of the voussoirs and the vertical corners of the buttresses to create a sharp line known as a tooled arris. This type of tooling is known as a "draft" or "margin" when applied around the perimeter of a stone's face.

The top and bottom of the stones, which form the bed joint, have been so precisely cut and smoothed that in many places the joints are less than 1/16" wide and most are less than 1/4" wide. The sides of the stone, which form the vertical joints, are also carefully smoothed, not so precisely as the beds, but still in the range of 1/4" to 1/2" except where spreading has occurred. This work was tediously done by hand with a hammer and chisel for the primary purpose of attaining a large area of frictional contact between the stones to resist lateral displacement by sliding. The extra labor cost for such good mating surfaces was partly offset by the need for less mortar.

Mortar is evident in most of the bed joints and in many of the vertical joints. Some bed joints appear dry laid (without mortar) but are so narrow they cannot be probed with a tool to determine if mortar is present. It can be assumed that high quality masonry work like this would have required that all stones be bedded with mortar. The skilled mason used just enough mortar so that it squeezed out close to the edge without running down the face of the stone. Some vertical joints are either completely missing their mortar or none was used. It was typical practice to leave occasional vertical joints open, without mortar, as "weep holes" to allow water to drain from behind the wall. Other vertical joints have obviously shifted and the loosened mortar fallen out.

Two types of mortar are present, one a soft, brownish mortar, presumed to be original and the other a gray-colored mortar typical of modern Portland cement mortars that was apparently used for later repair work. James L. Garvin, New Hampshire State Architectural Historian, examined and tested mortar samples from the bridge in 2006 and found evidence suggesting the presence of a natural cement mortar of the Rosendale type.[6] Standard petrographic analysis and scanning electron microscopic analysis recently performed on original mortar samples detected a mix of approximately 1 part lime-cement paste to 2 parts sand and other minerals suggesting the possible presence of a portland-type cement.[7] According to Dennis E. Howe, an industrial historian who has studied early American cement production and use, the original mortar was almost certainly made with Rosendale cement, a limestone-based hydraulic cement brown in color extensively used by the railroads during the nineteenth century.[8] Rosendale cement was widely used for hydraulic mortar throughout New England from the 1830s through the 1870s.[9] Cheshire Mill No. 1, a granite building constructed in 1846 in Harrisville, New Hampshire, a short distance east of Keene, is but one example.[10]

HISTORICAL BACKGROUND

Establishment of the Cheshire Railroad

The Cheshire Railroad Stone Arch Bridge over Branch River in Keene New Hampshire was built in 1846-1847 in conjunction with the construction of the Cheshire Railroad, 1845 to 1849, from South Ashburnham, Massachusetts, through Keene, to Bellows Falls, Vermont. The 1830s and 1840s was a time of great expansion of the railroads throughout New England as virtually every city and town of any size sought to build a connecting line to import and export goods to and from the major transportation hubs of Portland, Boston, New York and Montreal. The charter of the Boston and Worcester Railroad in 1831 and its successful opening in 1835 excited a frenzy of proposals by financially capable and incapable entrepreneurs. Railroad developers in Keene led by Salma Hale petitioned the state legislature in 1835 to build a railroad described in the charter as follows:

> Rail Road beginning at the village in the town of Keene and county of Cheshire, and thence running to the line of this State, terminating in the town of Fitzwilliam or Rindge in the direction towards Worcester in the State of Massachusetts, or in an easterly direction on such route or track as shall combine shortness of distance with the most practicable ground, in such manner and form as by said corporation may be deemed expedient. [11]

The charter for the Keene Railroad Company was granted in 1835, but the estimated construction costs outweighed the enthusiasm of investors and nothing became of the venture.

Another developer motivated by the building of the Boston and Worcester Railroad was Alvah Crocker, a paper manufacturer in Fitchburg Massachusetts who saw the great advantage that his competitors in Worcester had gained. In November of 1841 Crocker organized a group of fellow Fitchburg investors interested in building a railroad to Boston. Members of the group were dispatched to towns along the proposed route and potential extensions to the west and north to measure the interest of potential investors. Representatives were invited to a "Railroad Meeting" held in 1841 in Waltham, where resolutions were passed and committees established to survey the route and solicit subscriptions for stock. In attendance, representing the interests of Keene, were Salma Hale and Thomas Edwards.

On March 3, 1842 the Fitchburg Railroad Company was incorporated. In the pursuit of stock subscriptions, Crocker addressed meetings in Boston, Charlestown, Greenfield, Keene and Brattleboro, the intent at the time being to extend the line to Brattleboro either through Greenfield or Keene, ultimately forming a route to Burlington, Vermont and Montreal. His appearance at Keene Town Hall in December 1842 generated considerable excitement, as did the election of Thomas Edwards to the Board of Directors of the Fitchburg Railroad in January 1843.

Despite having gained a "seat at the table" in the direction of the Fitchburg, Keene's future as a railroad town was still in no way guaranteed and during 1843 two developments seriously threatened its prospects. Upon completing their surveys, the Fitchburg's engineers favored the route to Brattleboro by way of Greenfield. This was soon followed by the chartering of the

Brattleboro and Fitchburg Railroad in Vermont in October by interests that sought to connect with the Fitchburg at Greenfield. Construction of the Fitchburg line began in the spring of 1843. With no more time to waste, Salma Hale and Thomas Edwards organized a meeting at the Keene Congregational Church in December 1843 to form a railroad corporation and accept subscriptions for stock. The sum of $40,000 was quickly raised and in May and June 1844, an engineering survey of a possible route was conducted, apparently using some of the subscription funds. The survey produced a map entitled "Winchendon, Keene and Bellows Falls Rail-way." [12]

With a proposed route in hand, a series of petitions were then presented to the New Hampshire legislature in 1844, "praying for a charter for a Railroad from the southern boundary of the State at Fitzwilliam or Rindge, to the western boundary thereof, at Walpole or Charlestown." [13]

> Selma Hale presented the petition of George Huntington signed by 1594 others, legal voters in the counties of Cheshire and Sullivan; Mr. Parker of Fitzwilliam presented the petition of Asa Wentworth and 144 others inhabitants of the village of Bellows Falls, Vermont; Mr. Hale presented the petition of George T. Hodges and 81 others, citizens of Rutland Vermont; Mr. Fisher presented the petition of Charles Stevens and others, inhabitants of Ashburnham, Massachusetts.

With the petitions in the Senate record, Hale introduced a bill on June 18th, 1844 entitled "An Act to incorporate the Fitchburg, Keene and Connecticut River Railroad Company" and the next day the Senate approved the Act.[14] Unfortunately the charter of the corporation failed to adequately explain how claims for damages resulting from the construction of the railroad would be addressed and several months later it was rejected. A new charter with more conditions was drawn up and submitted under the name of Cheshire Railroad Company, which was enacted and approved December 27, 1844.[15]

The charter authorized the corporation to construct a line “from any point on the south [boundary] line of the State [of New Hampshire], in Fitzwilliam or Rindge, and passing thence through the village of Keene, to the western boundary of the State, in Walpole or Charlestown,” and further authorized the corporation to build a bridge across the Connecticut River to connect with Rockingham, Vermont.[16] A second New Hampshire law, passed on December 27, 1844, authorized the Cheshire Railroad to “unite with the Winchendon [Massachusetts] railroad corporation . . . and when said corporations shall have united . . . under the name of the Cheshire railroad company . . . all the franchises, property, powers and privileges granted and acquired under the authority of the states of New Hampshire and Massachusetts respectively, shall be held and enjoyed by all the said stockholders, in proportion to the amount of property or interest held by them respectively, in either or both of said companies or corporations.”[17]

By this means, the Cheshire Railroad secured authority to connect Winchendon, Massachusetts, and Rockingham, Vermont, by rail. Further action by the Massachusetts legislature authorized construction of six miles of track connecting Winchendon and Fitchburg, Massachusetts, thereby making legal a complete rail route passing through Keene from Boston to the Connecticut River at Walpole, New Hampshire, and Rockingham, Vermont.[18]

Design & Construction of the Cheshire Railroad Stone Arch Bridge

Shortly after the railroad was incorporated on December 27, 1844, "Messrs Whitwell and Tilton, Chief Engineers" were hired to survey and layout the final route of the line in preparation to the issuing of contracts for construction (Tilton and Whitwell are discussed below).[19] Plans were undoubtedly prepared showing the alignment and elevations, cuts and fills, and specifications for bridges and culverts, but none have been located. These two engineers presumably began work in the winter and early spring of 1845 when snow and the absence of leaves would have been advantageous to their surveying efforts. Two divisions of the road were laid out in New Hampshire in 1845 and contracts prepared and let in the early fall.

Work on the first division from the Massachusetts state line to Keene began on September 12, 1845. Work on the second division, from a separate point in Keene to the Connecticut River at Walpole began on October 25, 1845.[20]

Construction was pushed through the winter and on May 19, 1846, the Directors of the railroad reported on the progress in their First Annual Report:

> The whole amount of work from the beginning to the first of May, is as follows:[21]

Earth Excavation,	380,373	cubic yards.
Loose Rock "	1,850	" "
Solid Rock "	27,648	" "
Bridge Masonry	3,475	" "
Culvert "	2,324	" "
Arch "	146	" "

The exact date that the first stones were laid in the building of the Stone Arch Bridge over the Branch River in Keene has not been determined, but by October 13, 1846 the massive wood centering for the arch was at some stage of construction when it collapsed. The *Keene Sentinel* reported:

> In Keene little rain fell, but during the high winds which prevailed, the ‘great framework’ that had been built to support the erection of the stonework, fell, a complete ruin, with a loss to the contractor of several hundred dollars in addition to that caused by the delay.[22]

The only other mention of the arch construction project found in the newspapers of the day was again in the *Keene Sentinel*, two months later, when on December 9, 1846 it reported:

> The keystones of the great bridge (a magnificent structure) over the East Branch, in this town, were put in place last week, and the filling [over the arch] is now going on vigorously, as is the work on the whole line. The remaining sections to the Falls, we learn are soon to be put under contract.[23]

The date that the arch was considered complete is also not known, but must have been in early 1847. Construction of the line from Keene south continued "with the upmost diligence" through

1847 and into the spring of 1848.[24] Eight miles of the line opened from South Ashburnham to Winchendon on October 4, 1847 and by December 27, the twenty-two miles to Troy were open with one freight and two passenger trains running daily. The passenger trains were "run without a single interruption, and with the full average speed of New England railroads: performing its trips of twenty-two miles in an hour." [25] Work continued between Troy and Keene through the winter and spring of 1848 where several large rock cuts through granite made for slow going.

The Cheshire Railroad was opened to Keene with great fanfare on May 16, 1848. A special train from Boston arrived at 1:30 pm to an anxiously waiting crowd of over 5000 people.[26] Speeches were given and the annual meeting of the corporation was convened in the old town hall. After the meeting

> "the entire procession reformed and march to the [new] depot, where those in charge had caused to be set on the depot platform, which was 200 feet long, four rows of tables for its entire length, or 800 feet of tables, loaded with the substantials which the inner man demanded." [27]

Work on the northern division of the line encountered more difficulties making the rock cuts at the summit of the line near the junction of the towns of Keene, Surry and Westmoreland but nonetheless was completed for a January 1, 1849 opening of the line to the east bank of the Connecticut River opposite Bellows Falls.[28] The bridge over the river, a two span covered wood truss and wood arch bridge, was completed about six months later, marking the northern terminus of the line where it joined the Rutland Railroad to form a continuous route from Boston to Montreal.

The Cheshire Railroad was sold to the Fitchburg Railroad on September 3, 1890. The Fitchburg made major improvements to its line in 1899, including the building of a new bridge over the Connecticut River, at Bellows Falls, described elsewhere in this report.

The Boston and Maine Railroad leased the Fitchburg the line in 1900 as part of its expanding takeover of New England lines. "Crack express trains like the *Green Mountain Flyer* and the *Mount Royal* used the Cheshire on the Boston-Fitchburg-Bellows Falls-Rutland-Montreal route, until the Rutland discontinued service in 1953. The B&M continued passenger trains on the line another five years."[29]

The Cheshire Railroad was officially abandoned along most of its length in 1972.[30] In the early 1990s, the New Hampshire Department of Transportation purchased approximately forty linear miles of the railroad in the towns and cities of Fitzwilliam, Troy, Marlborough, Swanzey, Keene, Surry, Westmoreland, and Walpole. In keeping with standard practice, this linear corridor was placed under the administrative care of DOT’s Bureau of Rail and Transit. The Bureau of Rail and Transit, in turn, has permitted the use of much of the line as a recreational trail under the Trails Bureau of the Department of Resources and Economic Development (DRED).

In 1994 the NHDOT undertook the preparation of a NHDHR Area Form on the entire Cheshire Railroad resource located within state boundaries.[31] The form noted the Cheshire Railroad as being "singular in the state for its high number of granite bridges and culverts, for the quality of construction, and for their survival." A comparison of the stone arch structures along the Cheshire Railroad line is provided in the table below.

Stone arch bridges and stone arch culverts on the former Cheshire Railroad line

Structure Type	**Mile Point**	**Crossing over**	**Town**	**Arch Type**	**Span (approx)**
2-arch bridge	71.08	stream	Fitzwilliam	elliptical	20'
bridge	73.32	Scott Brk	Fitzwilliam	3-centered	20'
culvert	76.79	steam	Fitzwilliam	stilted semicircular	6'
culvert	80.91	Rockwood Brk	Troy	stilted semicircular	12'
bridge	83.24	Ashuelot R.	Troy	elliptical	38'
bridge	85.45	Thatcher Hill Rd.	Marlboro	stilted semicircular	16'
culvert	86.73	Forbush Brk	Swanzey	stilted semicircular	6'
Subject Bridge	***89.41***	***Branch River***	***Keene***	***stilted semicircular***	***68'***
bridge	93.24	Ash Swamp Brk	Keene	semicircular	18' ?
culvert	94.54	stream	Keene	stilted semicircular	6'
bridge	94.57	Arch St.	Keene	segmental	20' ?
culvert	95.07	Hurricane Brk	Keene	stilted semicircular	9'
culvert	100.06	stream	Westmoreland	stilted semicircular?	13'
culvert	105.05	Aldrich Brk	Westmoreland	stilted semicircular?	12'
culvert	105.32	Houghton Brk	Walpole	segmental	20' ?
2-arch culvert	106.65	Great Brk	Walpole	stilted semicircular	15'
culvert	108.96	stream	Walpole	stilted semicircular?	4'
culvert	109.10	stream	Walpole	semicircular?	7'
culvert	110.35	stream	Walpole	semicircular?	12'

Engineer Biography: Lucian Tilton

In addition to participating in the survey of the route of the Cheshire Railroad, Tilton has been credited with the design of the Keene Arch:

> Mr. Lucian Tilton was chief engineer and the first superintendent [of the Cheshire Railroad], and the road was pronounced to be of superior character. The massive and graceful arch over the Branch at South Keene—a single span ninety feet broad and sixty feet high, designed by Mr. Tilton and built under his direction—is one of the finest of the kind in the country and worth traveling a long distance to see.[32]

A native of Hampton Falls, New Hampshire, Tilton (1812-1877) served as superintendent of the railroad upon its completion.[33] Tilton served as consulting engineer for the survey of the Ashuelot Railroad in 1847, which was completed between Keene and East Northfield, Massachusetts in 1850.[34] He was one of the founding (charter) members of the New England Association of Railway Superintendents formed on April 5, 1848. Among the other twenty founders were Charles Minot, Superintendent of the Boston & Maine Railroad and Samuel M. Felton, Superintendant of the Fitchburg Railroad.[35] Two years later Felton employed Tilton as superintendent of the Fitchburg Railroad in Massachusetts, a position he held from 1850 to 1853.[36]

Tilton subsequently served as superintendent of the Toledo and Wabash Railroad and as president of the Great Western Railroad; in the latter position, he and his family rented the home of the Abraham Lincoln family in Springfield, Illinois, when the Lincolns left for Washington, D.C. in January 1861.

Tilton moved to Chicago in 1869, and his house there was destroyed two years later in the great Chicago fire of October 8, 1871.[37] He was very interested in history and served on the Executive Committee of the Chicago Historical Society from 1871 to 1875. In 1873 he served as a director of the New York, West Shore and Chicago Railway Company.

Tilton died in Chicago on March 19, 1877 and left a "fortune of fully a quarter of a million dollars, mainly in cash and bonds, and it is stated a portion consists of $60,000 in gold, but recently purchased."[38] He lived at 297 Oak Street at the time of his death. His obituary referred to him as Colonel, although it was not determined how or when he achieved that rank. After his death, his wife gave $3000 to the Chicago Historical Society in his name. He was considered one of the most eminent railroad engineers in the United States.[39]

Lucian and his wife Lucretia J. Tilton, were childless and when she died in 1906 she left practically the entire estate of $225,000 to charitable institutions, including two in her home town of Keene: the Elliot City Hospital was given $6000; the Invalids Home was given $5000.[40]

Engineer Biography: William S. Whitwell

William Scollay Whitwell was born in 1809 in Augusta Maine. He died in Brookline Massachusetts in October or November of 1899. According to a note on his death in the November 11, 1899 issue of *The Engineering Record,* "he was educated in Boston schools and at the Lawrence Scientific School, finishing with a course in practical work in several machine shops. When he entered active engineering practice, railways were beginning to attract general attention, and his work on many lines gained for him a wide circle of acquaintances."

The earliest reference found to Whitwell's railroad work was in the survey of the route of the Western and Atlantic Railroad from Atlanta, Georgia to Chattanooga, Tennessee in 1837 under the direction of the railroad's chief engineer Stephen Harriman Long.[41] Long (1784-1864) was a New Hampshire native who became a famous Army topographical engineer, railroad and bridge engineer.

In June 1846 Whitwell was elected Chief Engineer of the Eastern Division of the newly formed Boston Water Commission whose purpose was to build reservoirs and a water supply system for the City. He was responsible for the design and construction of the City's first water system known as the Cochituate Water Works.[42]

Whitwell was one of the founding directors of the Boston Society of Civil Engineers, established in 1848.[43] His work on Boston's water supply earned him national recognition in that field and in 1850 he was appointed the first chief engineer of the Jersey City Water Works where he designed a complex system with that included three large reservoirs.[44]

In 1863, in the capacity of Supervising State Engineer for Massachusetts, he directed the sinking of the Central Shaft of the Hoosac Tunnel. The risky project placed workers inside the mountain tunneling in opposite directions to meet the tunnels being driven in from each end and required extremely precise surveying methods. This effectively doubled the tunneling rate and cut the remaining completion time in half.[45]

STONE ARCH RAILROAD BRIDGES

Origins

During archeological excavations south of Bagdad, Iraq during the 1930's, the oldest known so-called true arch, or voussoir arch, as distinguished from pointed and corbelled arches, was discovered dating from roughly 3500 BC. The tiny stone arch was supporting the roof of a burial tomb in Ur, an area of Mesopotamia between the Tigris and Euphrates Rivers.[46]

The Etruscans were the first to put large voussoir arches into common use in building construction, and the Romans who followed them in time were the first to employ the voussoir arch in bridge building. The era of Roman stone arch bridge building spans from about 241 BC to about 200 AD. The Romans used only semi-circular arches (like the Keene Arch), the Pons Palatinus built in 181 BC with 80' spans being an early monumental example.[47] The first use of the segmental arch for a bridge is credited to Li Ch'un, a Chinese engineer who designed the Great Stone Bridge over the Chiao River in the 5th century AD.[48]

The rise of an arch is defined as the vertical distance between the plane of the spring point of the arch and the highest point of the intrados (the bottom of the keystone). The span and rise of a semi-circular arch is equal; as span increases the rise increases in direct proportion. The great height of long-span semi-circular arch bridges makes them unsuitable for many situations. The segmental arch, representing only a segment of a circle, has a span greater than its rise and therefore offers a larger opening with lower approaches and uses less material and labor than a semi-circular arch. Segmental arches with relatively low rise are often referred to as flat arches.

Technology

Up until about the 18th century, stones arches were designed by masons following the standards of common practice handed down to them. The first major development in arch theory was put forth by French engineer Phillippe de la Hire in his 1695 *Traite de Macanique*, in which he described his graphical method of analyzing forces acting on bodies in equilibrium, known as graphic statics today. For arches, la Hire proposed his "smooth voussoir" theory, which ignored friction between stones and employed force diagrams using polygons, later called the "line of force method." [49]

The pinnacle in stone arch bridge design can be considered to have been reached in the late 18th century by French engineer Jean-Rodolphe Perronet who applied the newly established principles of graphic statics to stone arch bridge design. Perronet was the first director of the

Ecole des Ponts et Chausses, the first civil engineering school in the world. His Pont de Neuilly over the Seine near Paris consisted of five low arches, each with a span of 120' and a rise of 30'. Although considered the most beautiful stone arch bridge ever built, the French government demolished and replaced the Pont de Neuilly with a modern highway span in 1956. The design survives however, in a copy built by the great English bridge builder Thomas Telford over the River Severn in Gloucester in 1827.[50]

Development to Decline

What is considered the earliest stone arch railroad bridge is the Causey Arch, completed in 1726 to serve the Grand Allies coal mining district at Tanfield, England. It carried three tracks of a horse-drawn colliery railroad over a stream at a height of 80 feet and a span of 105 feet. It was the longest bridge in England at the time and with its high earth-filled approaches it was thought to have been the largest civil engineering project in Great Britain since Roman times.[51]

In the United States an age of great stone arch railroad bridges began with the advent of the steam railroads. The oldest stone arch railroad bridge in the US is the Carrollton Viaduct, built in 1829 in Baltimore for the Baltimore and Ohio Railroad (B&O), one of the oldest railroads in the country. Like the Keene arch, it is a semi-circular arch of monumental size flanked by buttresses supporting the approach viaduct. Although called a viaduct, because of the high stone retaining wall approaches, the Carrollton bridge consists of the main span and just one additional small 18' side span over a wagon road along the riverbank. The term viaduct generally refers to a very long structure composed of many short identical spans, with perhaps one or two longer main spans over the watercourse. Viaducts were primarily built for railroads in order to cross wide valleys while maintaining a level grade with the surrounding countryside.

Several massive stone viaducts composed of a series of tall semi-circular arches – works of man unrivaled since the days of the Roman Empire – were erected by American railroads beginning in the 1830s. Under the direction of engineer Benjamin Latrobe, the B&O Railroad erected the Thomas Viaduct over the Patapsco River in Maryland between 1833 and 1835. With eight arch spans roughly 60 feet wide and 60 feet high, it was the largest bridge in the country at the time. At the same time in Massachusetts, the newly formed Boston & Providence Railroad was completing a massive stone viaduct over the Neponset River in Canton. Similar in overall magnitude to the Thomas Viaduct, the Canton Viaduct is a unique structure formed by high parallel stone retaining walls supported on each side by equally spaced buttresses along its entire length. The buttresses are joined at the top with segmental-arches, creating the appearance of a blind arcade.

During the 1830s and 1840s, scores of stone arch railroad bridges and viaducts were erected in Massachusetts, perhaps more than in any other state. Twenty railroads were built or under construction during the period and the abundance of high quality granite quarries and masons provided ready materials and labor.[52] Railroads like the Cheshire immediately sprouted in the neighboring states to make connections with the Massachusetts roads in order to reach Boston and other New England ports, and points north and west.

Several of the early railroads extending west from Boston, including the Boston and Worcester Railroad, the Western Railroad and ultimately the Fitchburg Railroad to which the Cheshire Railroad made its connection, built a large number of stone arch bridges and undoubtedly influenced the engineers of the Cheshire to follow suit.[53]

When the Keene arch was being completed in 1847 to 1848, the famous Starrucca Viaduct in Susquehanna, Pennsylvania was being built by the New York and Erie Railroad. The largest and most expensive bridge in the world up to that time, it is 1040 feet long overall with seventeen semi-circular arches each spanning 50 feet and standing 100 feet high.[54]

By the mid-19th century the use of the stone arch was in rapid decline due to the advent of truss bridges of wood and iron, all iron, and finally all steel construction. This was especially true in the United States where the railroads – during their initial building and period of expansion – demanded cheap and rapidly constructed bridges, characteristics stone arches did not possess. Railroads continued to be speculative enterprises and naturally pursued a policy of least possible capital investment, which translated to scant concern for a bridge's potential service life. During the second-half of the 19th century the weight of trains increased so greatly and rapidly that railroad bridges were replaced after as little as ten years service.

Revival

A number of factors came together toward the end of the 19th century that ushered in a revival of the stone arch bridge in America and Europe for highways and railroads. According to engineer Albert Buel, bridge building at that time was marked by "a tendency toward building more substantial structures" that stimulated "renewed interest in that most beautiful class of bridges, the masonry arch."[55] Buel attributed the revival to not only the beauty and permanence of stone arches, but "the recent development and promulgation of methods [of arch analysis] that compare favorably in exactness and simplicity with those used for the truss."[56] The London journal *The Engineer* editorialized that the revival of the stone arch was due to it being "incompressible, inflexible, indeformable, and practically, under normal conditions, imperishable."[57]

A significant attribute of the stone arch bridge is its great dead weight, which being many times greater than the live loads, makes it more resistant to vibration, overloading and the shock of impact loads (moving live loads) than other bridge forms. This "insistent ponderosity," as the British put it, and its permanence, again made the stone arch the choice for railroad bridges at the end of the century when the cost of continually replacing metal bridges that had deteriorated or were too light for the ever increasing weight of new locomotives.[58]

In the United States the stone arch bridge revival is considered to have begun in 1888 when the Pennsylvania Railroad began a system-wide bridge replacement program using stone arch construction wherever it was feasible. Railroads were busy at the time replacing or reinforcing their bridges to accommodate the new generation of heavier locomotives. Wealthy railroads like the Pennsylvania chose to build "permanent" stone arch bridges capable of carrying any foreseeable loading that the future might bring. Although more expensive in first cost, the were the least expensive in life cycle cost since maintenance and replacement costs could be considered almost zero. Many monumental multi-span stone arch bridges were constructed under the program and several received wide publicity in both the engineering and popular press. The four-track, 48-span Rockville Bridge over the Susquehanna River built in 1901 with an overall length of 3820 feet, was the crowning achievement of the project and remains the largest stone arch railway bridge in the world.[59]

During this time, in 1899 and 1900, a campaign of stone arch bridge construction on the Fitchburg Railroad, the new owner of the Cheshire Railroad, captured the attention of New England's bridge building community.[60] For the Fitchburg, the decision to build five new arch bridges of stone instead of steel was an economical one driven by first cost rather than life-cycle cost that motivated the PRR. A great shortage of structural steel during 1899 pushed prices up nearly two-fold and added long waits for delivery. Among the bridges replaced was the Cheshire Railroad's two-span, two-track covered wood bridge over the Connecticut River at Bellows Falls, which for almost twenty years had been limited to single track use due to insufficient load capacity.

> The site of the bridge, which is almost directly over the falls, is particularly well adapted for arches, as the bed and banks of the river are of solid ledge, and there is a natural pier of rock in the middle of the river, dividing the stream into two channels… It was found that stone arches for a double track bridge could be built for a little more than a single-track steel bridge, and for considerably less than a double-track steel bridge would cost.[61]

The resulting bridge consisted of two spans of 140 feet each, with a rise of only twenty feet, "giving this bridge two of the longest masonry arches, with the least rise, in the United States."[62]

SIGNIFICANCE

The Cheshire Railroad was significant to the development of the city of Keene and Cheshire County New Hampshire, and an important link in the railroad transportation network of New England for over 100 years.

The Cheshire Railroad surpassed all other rail lines in New Hampshire in its mastery of masonry construction and in the bold use of the stone arch for its many stream crossings.[63] The Cheshire Railroad was characterized as "one of the most thoroughly-constructed roads in the country. Its bridges, culverts and abutments, built of cut granite, are models of civil engineering."[64]

The Cheshire Railroad Stone Arch Bridge over the Branch River in Keene, New Hampshire ranks among the most impressive masonry arches to be constructed in the United States before 1850. It exhibits an uncommonly high level of design and workmanship exemplified by the curved granite wingwalls and use of precisely squared granite ashlar masonry for the entire structure. It is the largest of twenty impressive stone arched bridges and culverts built under the supervision of Chief Engineers William S. Whitwell and Lucian Tilton, for the Cheshire Railroad. Whitwell and Tilton were accomplished engineers and founders of their profession in the United States.

END NOTES

[1] The Branch River is located entirely in the city of Keene and paralleled along its entire 2.6 mile length by NH Route 101. It was sometimes considered to be part of Otter Brook; a 1982 decision by the federal Board of Geographic Names established the name "The Branch." wikipedia.com.

[2] Keene History Committee, *"Upper Ashuelot," A History of Keene, New Hampshire* (Keene, N. H.: by the committee, 1968), pp. 89, 288, 395. C.H. Hitchcock (1878) describes three granite quarries that operated in Roxbury: "the southwest corner of Roxbury has [three] valuable granite quarries. The largest is Keene Granite Company… 2 miles northeast from South Keene station… opened about 1850. The Cheshire Granite Company… a third of a mile west of the last. Another quarry, opened about 1840, now owned by John L. Randall, of Albany, N.Y., is situated one mile north-east from these, being about four miles from Keene… has been worked since 1873 by Nourse & Dean, of Keene."

[3] Charles H. Hitchcock. *The Geology of New Hampshire* (Concord: Edward A. Jenks, State Printer, 1878), pp. 76-77. Cheshire County and Environs Bedrock Map, in Charles H. Hitchcock. *Geologic Atlas of New Hampshire* (Concord: Edson C. Eastman, Publisher, 1878). See also: USGS Simplified Bedrock Geologic Map of New Hampshire, 1997 and USGS NH Geologic map data at: http://tin.er.usgs.gov/geology/state/state.php?state=NH.

[4] Hitchcock, 1878, p. 76.

[5] David Proper, "For decades, bridges stood over troubled water," *The Keene Sentinel*, March 28, 2006, paraphrasing Clifford C. Wilber, "Iron Railing on Stone Arch Bridge," "The Good Old Days" No. 486, *The Keene Sentinel*, December 10, 1936; Keene *Repertory* Almanac, p. 557.

[6] James L. Garvin, in an email memo (12/18/2009) states that he performed "an acid dissolution test on this brownish mortar in 2006. The result of dissolving as much of the mortar as possible in acid, and examining the residue, led me to say in the survey form for the bridge that 'Many of the joints between the stones of the vault, the spandrel walls, the piers, and the wing walls have no visible mortar. Many of the beds of the stones appear to have been hammered to a fineness that permitted the stones to be laid dry, yet to achieve good surface contact. But some joints in the bridge are filled with a soft, brownish mortar. Preliminary tests suggest that this mortar may include some natural cement in addition to lime and sand. The mortar appears to have been employed only where irregularities in the beds of adjacent stones required a cushion to achieve even contact through the mass of masonry.' Much of the lime content dissolved in the acid, but there was a cementitious residue that I presumed to be that of the insoluble components of Rosendale cement."

[7] David Gress. Cheshire Railroad Stone Arch Mortar Evaluation. Prepared for CHA, Inc., Albany, NY, July 31, 2009. Guise detected the presence of "slender fibers [that] appear to be ettringite. This suggests there were at least some original components within the original mortar cement that were portland cement."

[8] Telephone interview of Dennis E. Howe, Concord, New Hampshire, January 9, 2010. Howe is the author of "An Archeological Survey of the Whiteport Cement Works," IA The Journal of the Society for Industrial Archeology, 33.1 (2007) and The Industrial Archeology of a Rosendale Cement Works at Whiteport (privately published, 2009).

[9] Extensive information on the history, use and manufacture of natural cements, especially Rosendale Cement, can be found in Natural *Cement,* edited by Michael P. Edison, 57-67. West Conshohocken, PA: ASTM, 2008. The book is a compilation of papers presented at the First and Second American Natural Cement Conferences held in 2005 and 2006.

[10] Linda Willett and Frederick O'Connor. "Masonry Repairs at Cheshire Mill No. 1, Harrisville, New Hampshire," in *Natural Cement,* edited by Michael P. Edison, 57-67. West Conshohocken, PA: ASTM, 2008.

[11] Laws of New Hampshire, Chapter 68, "An Act to Incorporate the Keene Rail Road Company." Acts, vol. 31, p. 143, Approved June 27, 1835.

[12] Donald B. Valentine. "A Brief History of the Cheshire Railroad," *The New England States Limited* (Summer 1977): 20.

[13] New Hampshire. *Journal of the Honorable Senate of the State of New Hampshire at their Session Held at the Capitol, in Concord, Commencing Wednesday, June 5, 1844* (Concord: Carroll & Baker, State Printers, 1844), pp. 49, 59, 103, 126.

[14] New Hampshire. *Laws of the State of New Hampshire, from November Session, 1842, to June Session, 1847, Inclusive.* Private Acts, Chapter 112 (Concord: Butterfield & Hill, State Printers, 1847), p. 103.

[15] Ibid., Private Acts, Chapter 192, p. 187.

[16] *By-Laws and Act of Incorporation of the Cheshire Railroad Company and General Railroad Laws* (Keene, N. H.: Printed by H. A. Bill, 1845).
[17] *Ibid*.
[18] *First Annual Report of the Directors of the Cheshire Railroad Company, to the Corporation* (Keene, N. H.: J. & J. W. Prentiss, 1846).
[19] *Ibid.*
[20] *First Annual Report of the Cheshire Railroad Company*, 1846, p.4.
[21] *First Annual Report of the Cheshire Railroad Company*, 1846, p.6.
[22] Clifford C. Wilber, "Stone Arch Railroad Bridge," "The Good Old Days" No. 472, *The Keene Sentinel*, November 23, 1936.
[23] *New-Hampshire Sentinel* (Keene, New Hampshire), December 9, 1846.
[24] *Third Annual Report of the Cheshire Railroad Company*, 1848, p.1.
[25] *Ibid.*, p. 5.
[26] Clifford C. Wilber, *Centenary of the Opening of the Cheshire Railroad to Keene, N. H., May 16, 1848* (Keene, N. H.: Keene National Bank [1948]).
[27] *Ibid.*, p. 4.
[28] Valentine, "A Brief History of the Cheshire Railroad, 1977, pp. 21-22.
[29] Robert M. Lindsell, *The Rail Lines of Northern New England* (Pepperell, Mass.: Branch Line Press, 2000), p. 62.
[30] *Ibid*., p. 63.
[31] Elizabeth J. Hostutler. "Cheshire Railroad Area Form." New Hampshire Department of Transportation, 1994. On file at the New Hampshire Division of Historical Resources, Concord, NH.
[32] S. G. Griffin, *A History of the Town of Keene* (Keene, N. H.: Sentinel Printing Company, 1904; facsimile edition, Bowie, Maryland: Heritage Books, 1980), p. 446.
[33] Tilton's place and date of birth are supplied in an article by David Proper, "Lincoln never did stay here, but Keene man rented his home," *The Keene Sentinel*, February 11, 2003. The United States Census of 1850 listed Tilton as a resident of Keene, "age forty." His death date of March 19, 1877, in Chicago, is given in the *Cheshire Republican* (Keene, N. H.) for March 31, 1877.
[34] Marium E. Foster. "Transportation, Part One, Railroads," in Keene History Committee, *"Upper Ashuelot," A History of Keene, New Hampshire* (Keene, N. H.: by the committee, 1968), pp. 396-398.
[35] *Railway Age Gazette.* "Some Bits of Railway History." 51 (November 1911): 509-510.
[36] David Proper, "Lincoln never did stay here, but Keene man rented his home," *The Keene Sentinel*, February 11, 2003.
[37] National Park Service, website for "Lincoln Home National Historic Site: The Lincolns in Springfield, 1849-1861."
[38] *Chicago Daily Tribune.* Obituary. Col. Lucian Tilton. March 22, 1877.
[39] *The Repertory* (Keene, N. H., 1924-25), p. 189.
[40] *Chicago Daily Tribune.* Obituary. Mrs. Lucretia J. Tilton. November 5, 1906; Chicago Daily Tribune. Large Sums for Charity. November 16, 1906.
[41] See: [http://ngeorgia.com/ang/Stephen_Harriman_Long].
[42] Nathaniel J. Bindlee, *History of the Introduction of Pure Water into the City of Boston.* Boston: A. Mudge & Son Printers, 1868, pp. 95-96.
[43] *Journal of the Association of Engineering Societies*, v.1, no. 1 (November 1881), p. 7.
[44] Charles Winfield, *History of County of Hudson, New Jersey* (New York: Kennard and Hay Printing Co., 1874), p. 292.
[45] "Historical Notes on the Hoosac Tunnel." Online at: http://www.naplibrary.com/HTHistoricNotes.html
[46] Rudyard A. Jones, "The Origin of the Voussoir Arch." *Civil Engineering* (April 1941): 259.
[47] Jean-Pierre Adam, *Roman Building Materials and Techniques.* Translated by Anthony Mathews. (Bloomington, Indiana: Indiana University Press, 1994): 162.
[48] Roland Turner and Steven L. Goulden, Editors. *Great Engineers and Pioneers in Technology* (New York: St. Martin's Press, 1981): 118.
[49] *Ibid.*, pp. 227-228.
[50] James Kip Finch. "Transportation and Construction, 1300-1800." In *Technology in Western Civilization, v. 1.* Melvin Kranzberg and Carroll W. Pursell, Jr., Editors. (New York: Oxford University Press, 1967): 201-202. An

excellent history of England's stone arch bridges can be found in Eric de Mare, *The Bridges of Britain* (London: B.T. Batsford Ltd., 1954).

[51] Frederick C. Gamst. "The Context and Significance of America's First Railroad, on Boston's Beacon Hill." *Technology and Culture*, 33 (January 1992):77.

[52] Frederick C. Gamst, Editor. *Early American Railroads: Franz Anton Ritter von Gerstner's Die innern Communicationen.* Stanford, CA: Stanford University Press, 1997, p. 366.

[53] Steven Roper, MassHighway Structures Historian, personal communications, August 2009.

[54] Albert W. Buel, "The Merits and Permanency of the Masonry Arch Bridge." *Engineering Magazine*, 17 (April, 1899): 31; Charles S. Whitney. *Bridges: A Study in Their Art, Science, and Evolution* (New York: W. E. Rudge, 1929): 183, 186.

[55] Buel, 1899, p. 23.

[56] Buel, 1899, p. 36.

[57] "The Revival of the Stone Arch." *Engineer* (June 21, 1901): 638.

[58] *Ibid*., p. 639.

[59] *Engineering Record* 1901: 450-451; *Railroad Gazette.* "Stone Bridges on the Pennsylvania." 33 (August 16, 1901): 580. *Railroad Gazette.* "An Important Stone Arch Bridge." 33 (December 6, 1901): 846; *Scientific American Supplement* 1904: 23693.

[60] Albert S. Cheever, "Stone Arch Bridges Recently Constructed on the Fitchburg Railroad." *Journal of the Association of Engineering Societies*, 27 (July 1901): 1-8.

[61] Ibid., p. 2.

[62] Garvin, *NHDHR Inventory Form KEE0182*, 2006.

[63] Garvin, NHDHR Inventory Form KEE0182, 2006.

[64] D. Hamilton Hurd, ed., *History of Cheshire and Sullivan Counties, New Hampshire* (Philadelphia: J. W. Lewis & Company, 1886), p. 21.

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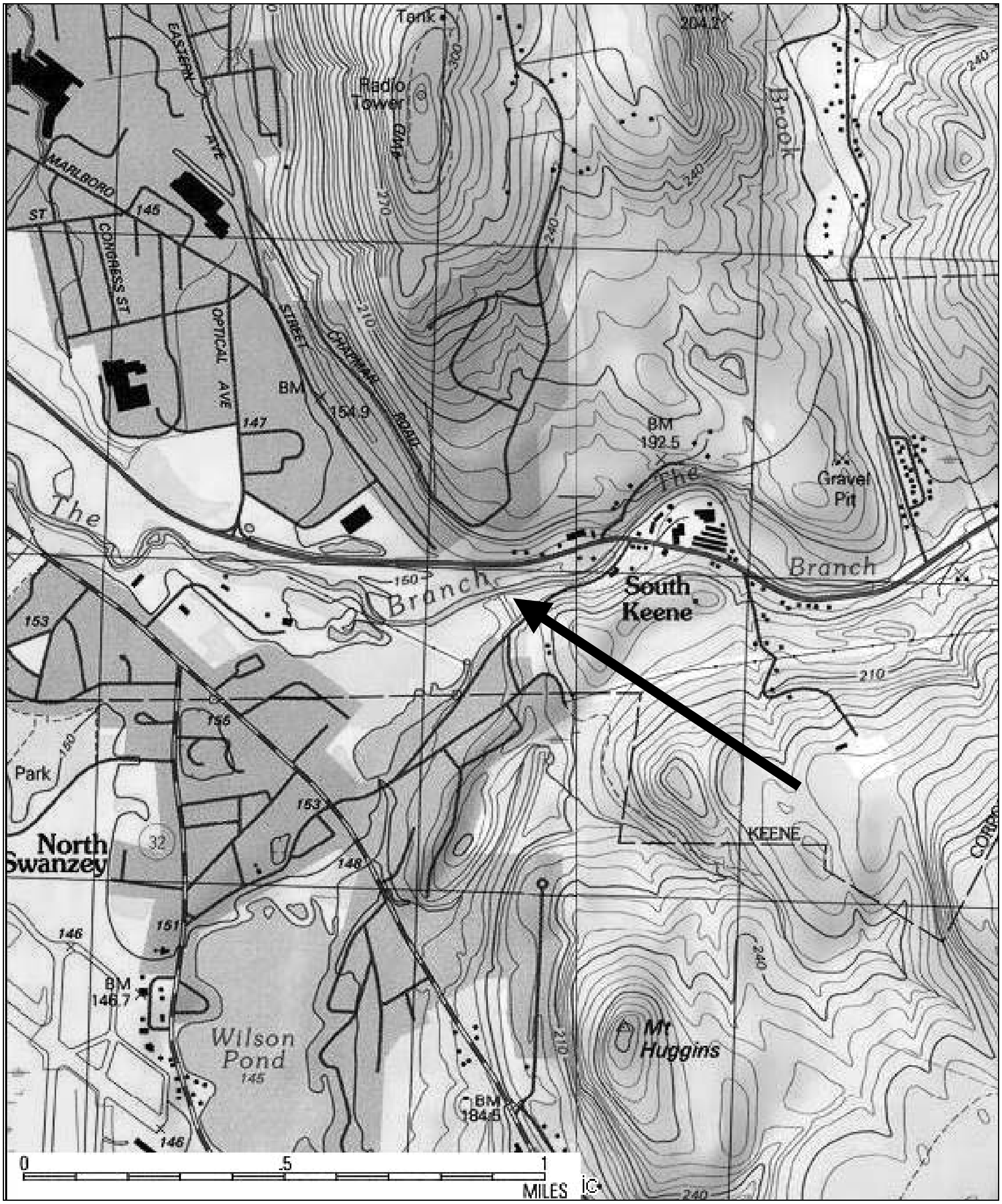
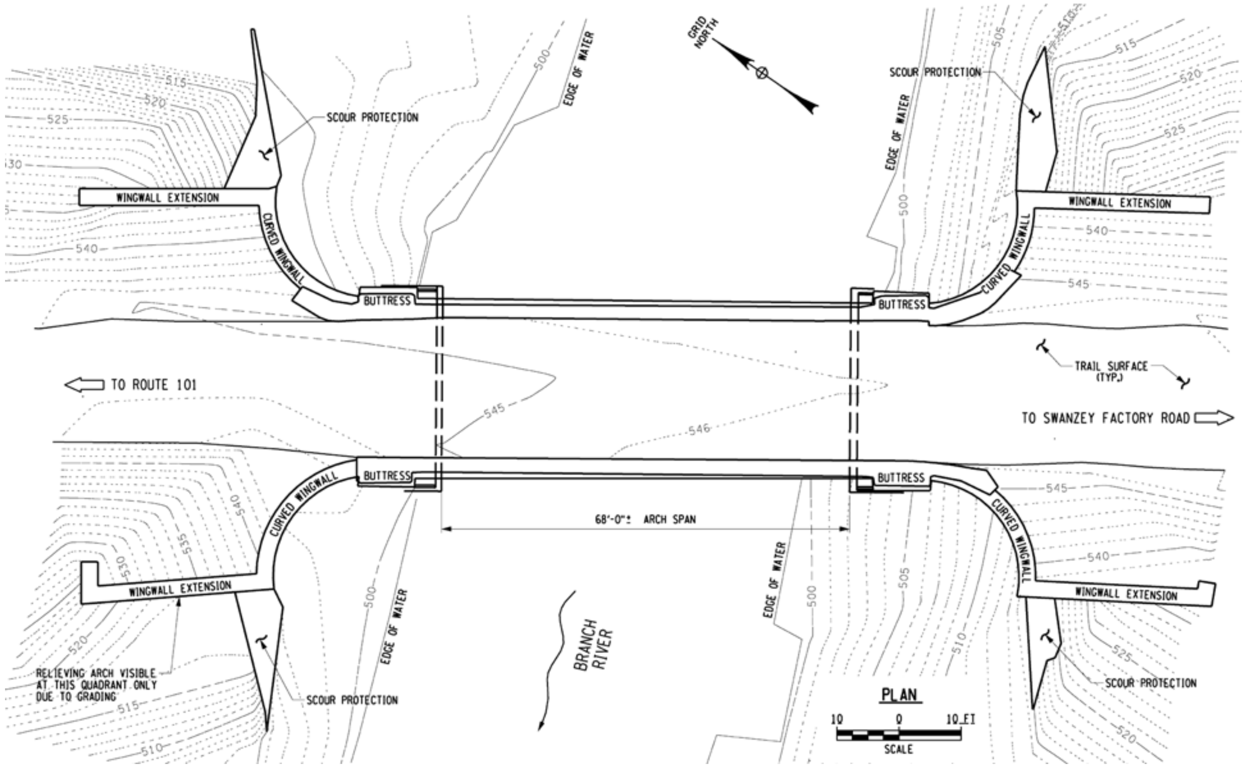


FIGURE 1: Location Map USGS Marlborough, NH quadrangle, 1998 current as of 1980.



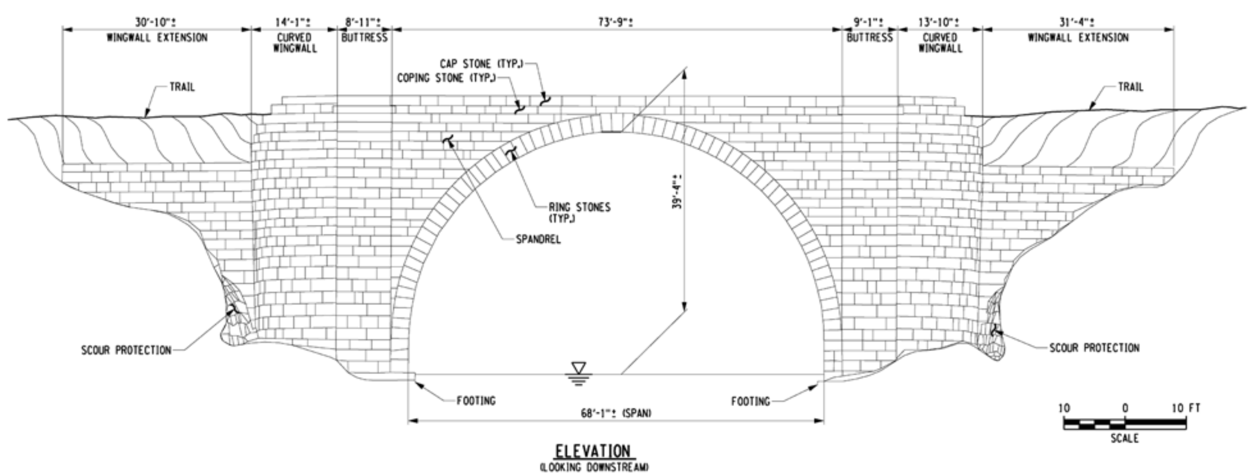
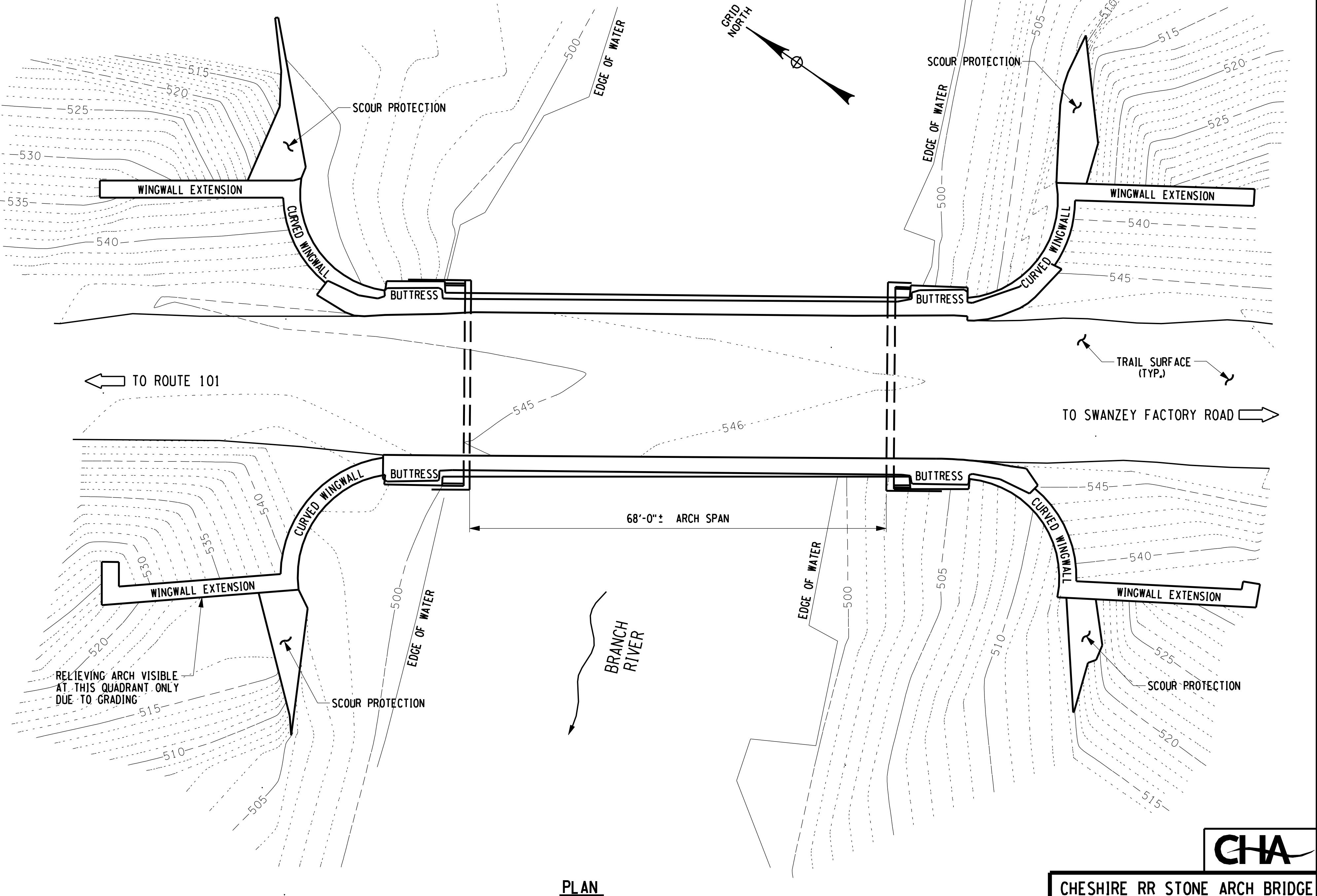


FIGURE 2: Property Sketch. Site Plan and elevation drawing from CHA measured drawings.

MEASURED DRAWINGS

Prepared by

CHA, Inc.
Albany, New York



PLAN

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SCALE

CHESHIRE RR STONE ARCH BRIDGE
CITY OF KEENE, N.H.

PLAN

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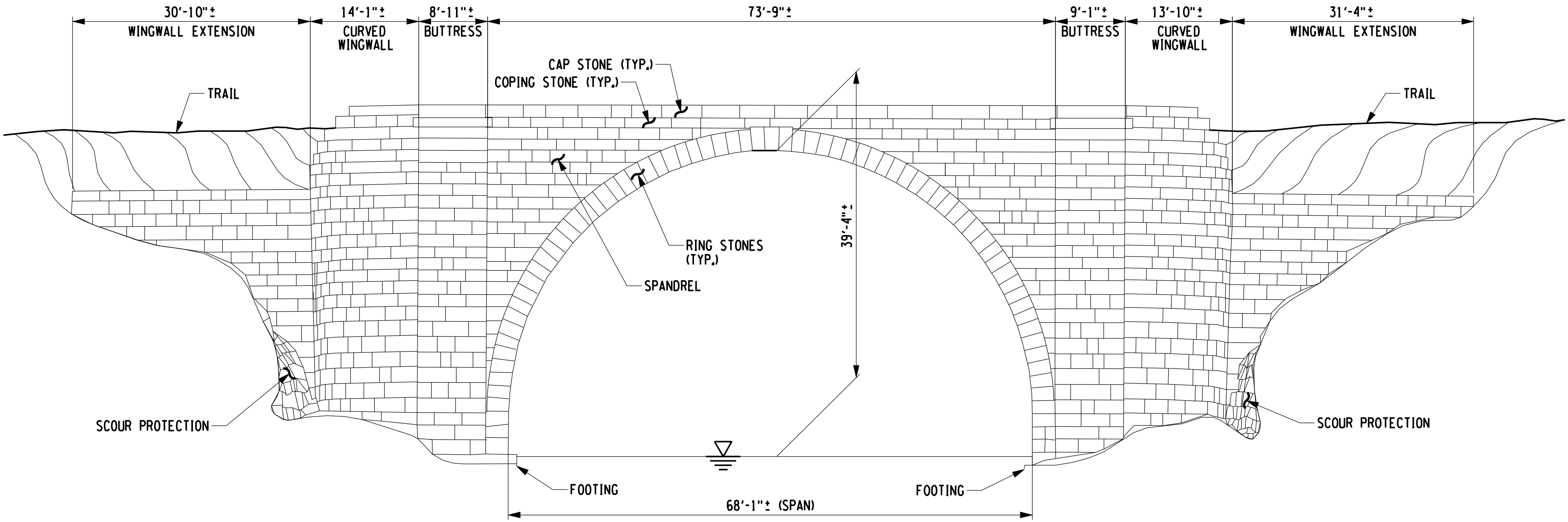
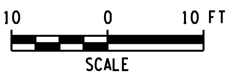


ELEVATION
(LOOKING DOWNSTREAM)



CHA

CHESHIRE RR STONE ARCH BRIDGE
CITY OF KEENE, N.H.

UPSTREAM ELEVATION

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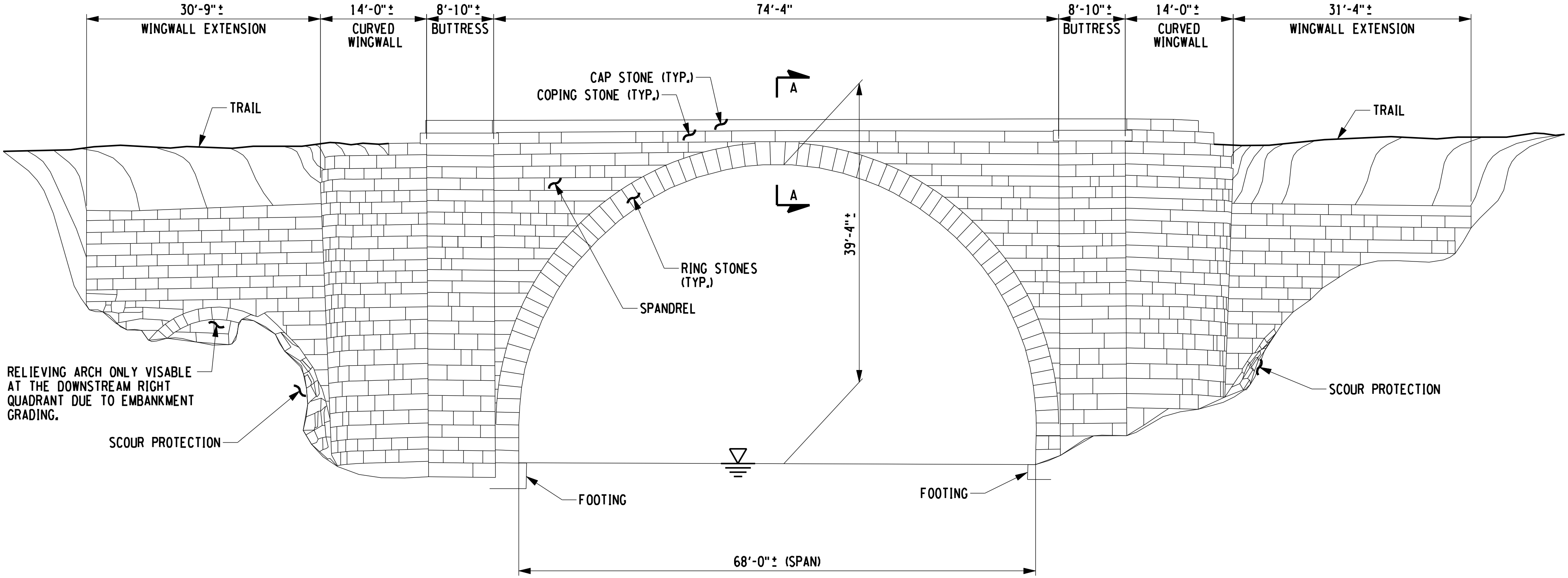

ELEVATION
(LOOKING UPSTREAM)

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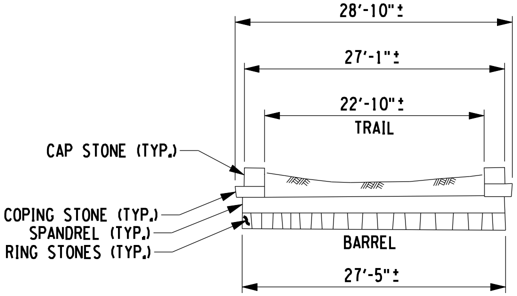

SECTION A-A

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DATE/TIME : 8/18/2009
USER : 3293

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CHESHIRE RR STONE ARCH BRIDGE
CITY OF KEENE, N.H.

DOWNSTREAM ELEVATION AND SECTION

INDEX TO PHOTOGRAPHS

CHESHIRE RAILROAD STONE ARCH BRIDGE
Former Cheshire Railroad/Boston & Maine Railroad Right-of-Way spanning Branch River
Keene,
Cheshire County,
New Hampshire

New Hampshire State No. 641
Photographer: Rob Tucher
May 2009

NH-630-1 View of bridge in context with Route 101. Looking southwest.

NH-630-2 View of bridge in context with floodplain. Looking southwest.

NH-630-3 Upstream elevation. Looking southwest.

NH-630-4 Downstream elevation, north half. Looking north.

NH-630-5 Downstream elevation, south half. Looking east.

NH-630-6 Detail of arch and buttresses, upstream side. Looking southwest.

NH-630-7 Southeast wingwall. Looking south.

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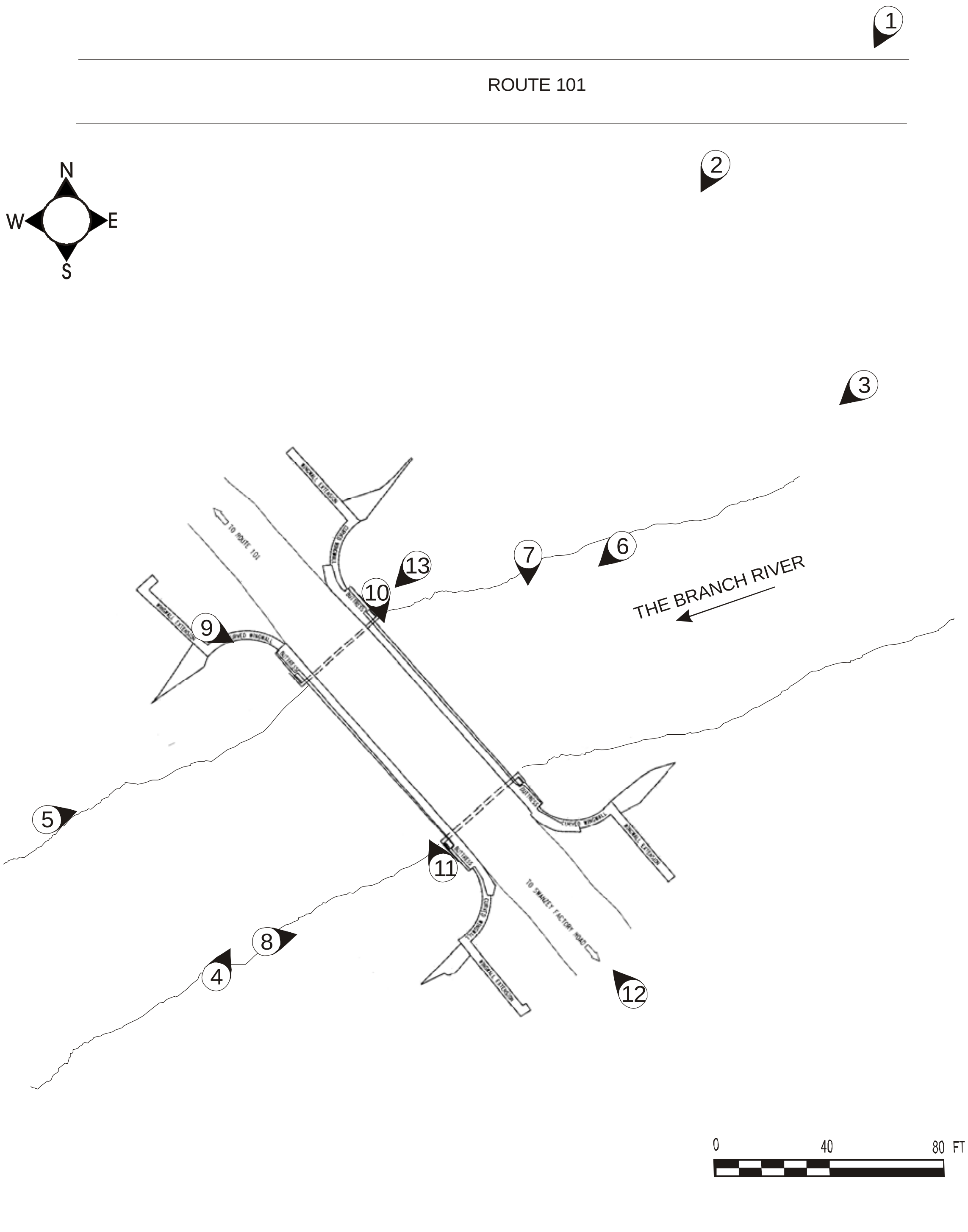
NH-630-12 Former railbed, now trail, over bridge. Looking northwest.

NH-630-13 Detail of arch and buttress stonework. Looking southwest.

CHESHIRE RAILROAD STONE ARCH BRIDGE
NH State No. 641
Key to Photographs



NH-630-1 View of bridge in context with Route 101. Looking southwest.

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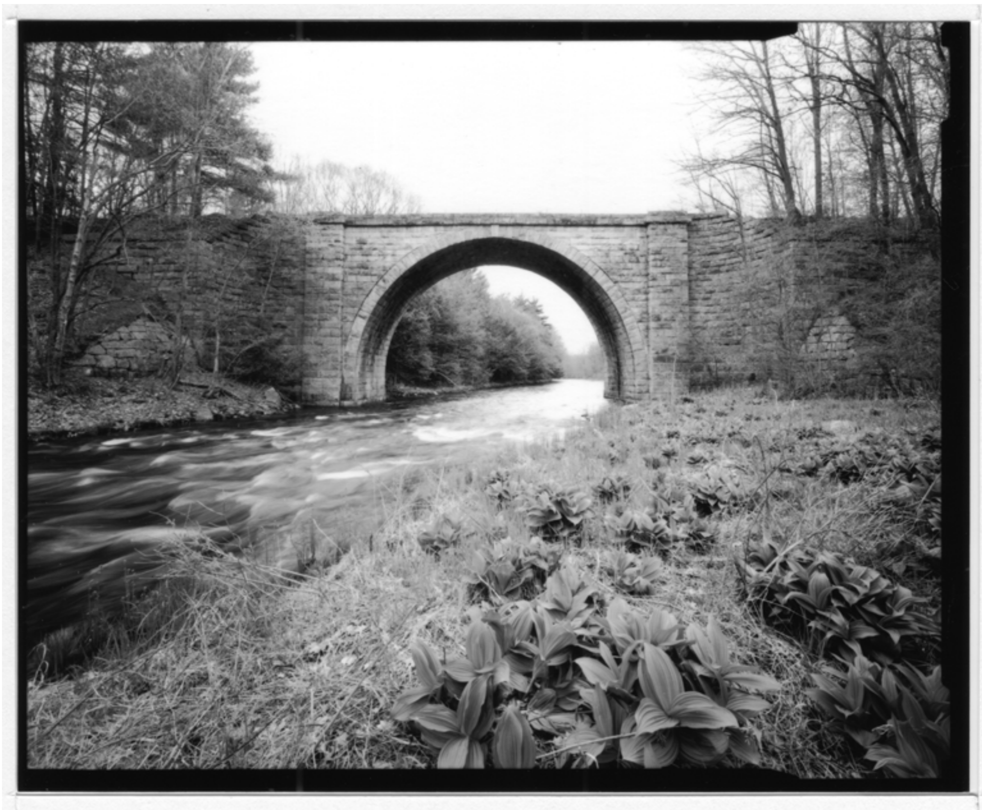
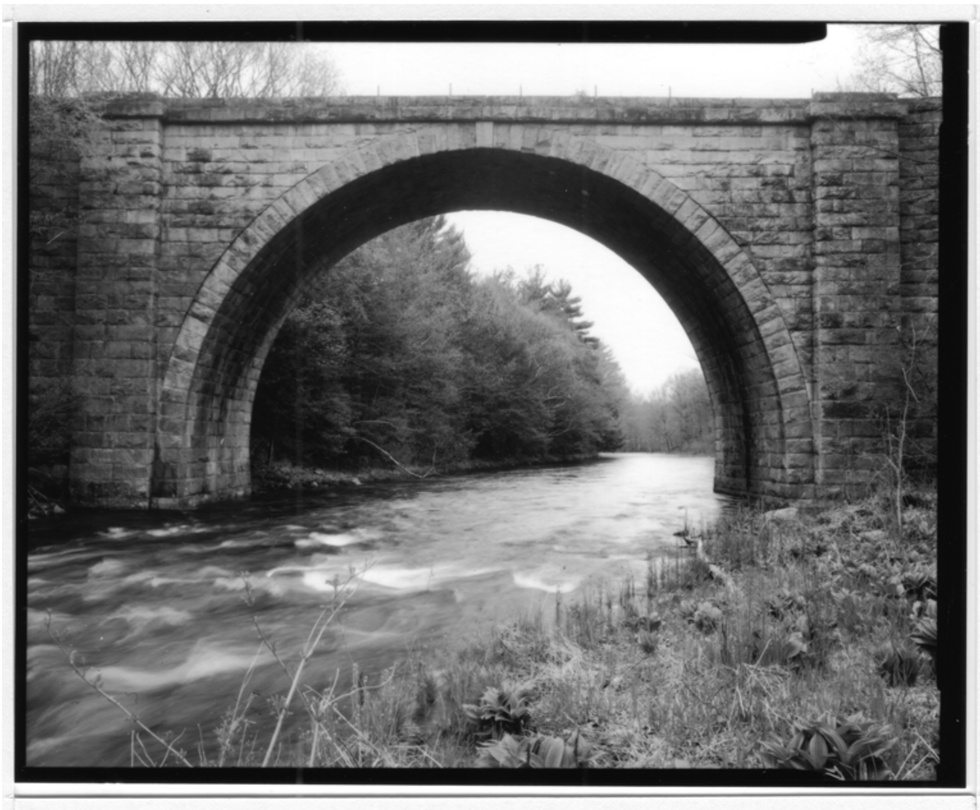
NH-630-3 Upstream elevation. Looking southwest.



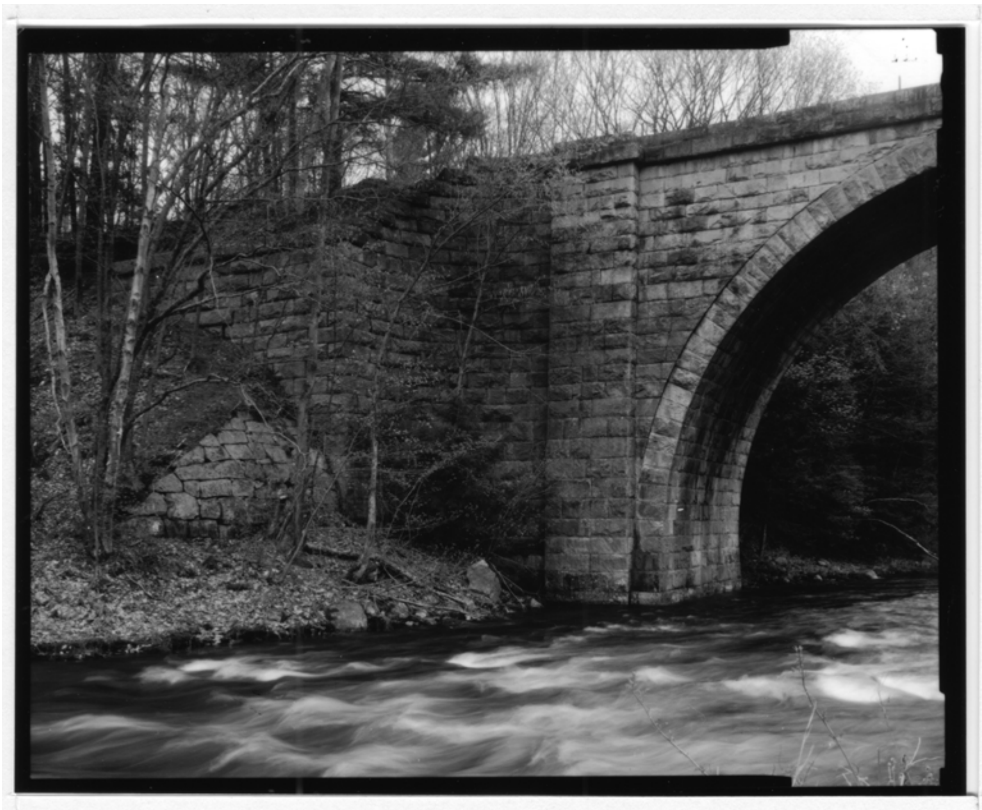
NH-630-4 Downstream elevation, north half. Looking north.

NH-630-5 Downstream elevation, south half. Looking east.

NH-630-6 Detail of arch and buttresses, upstream side. Looking southwest.

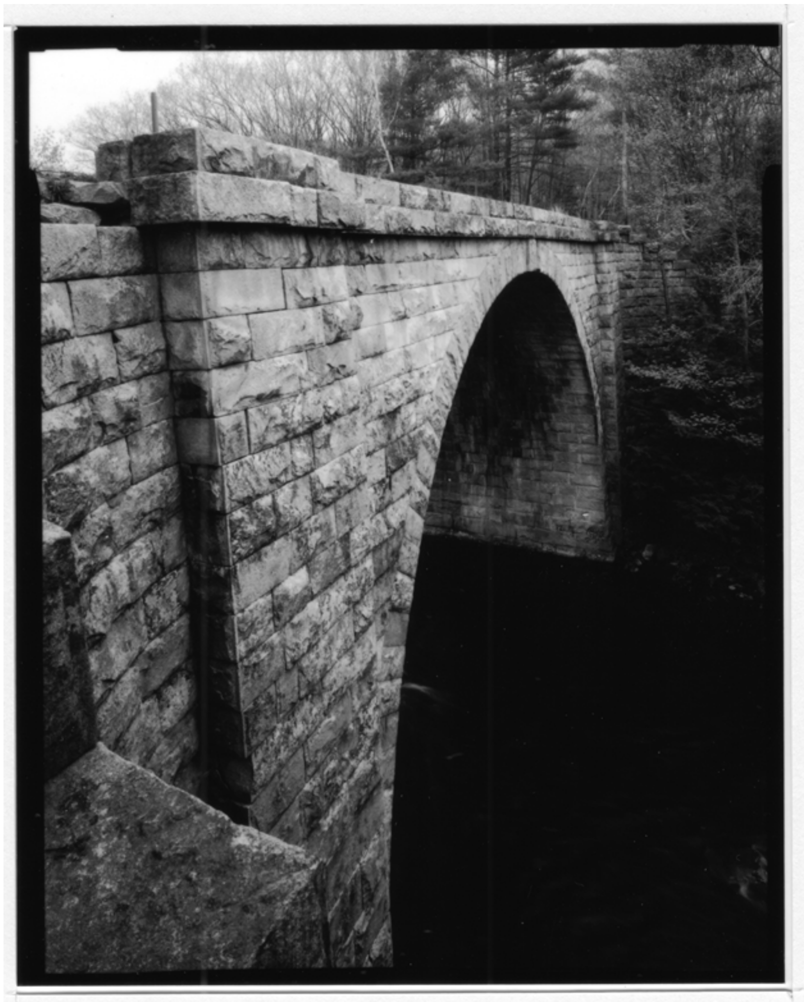


NH-630-7 Southeast wingwall. Looking south.

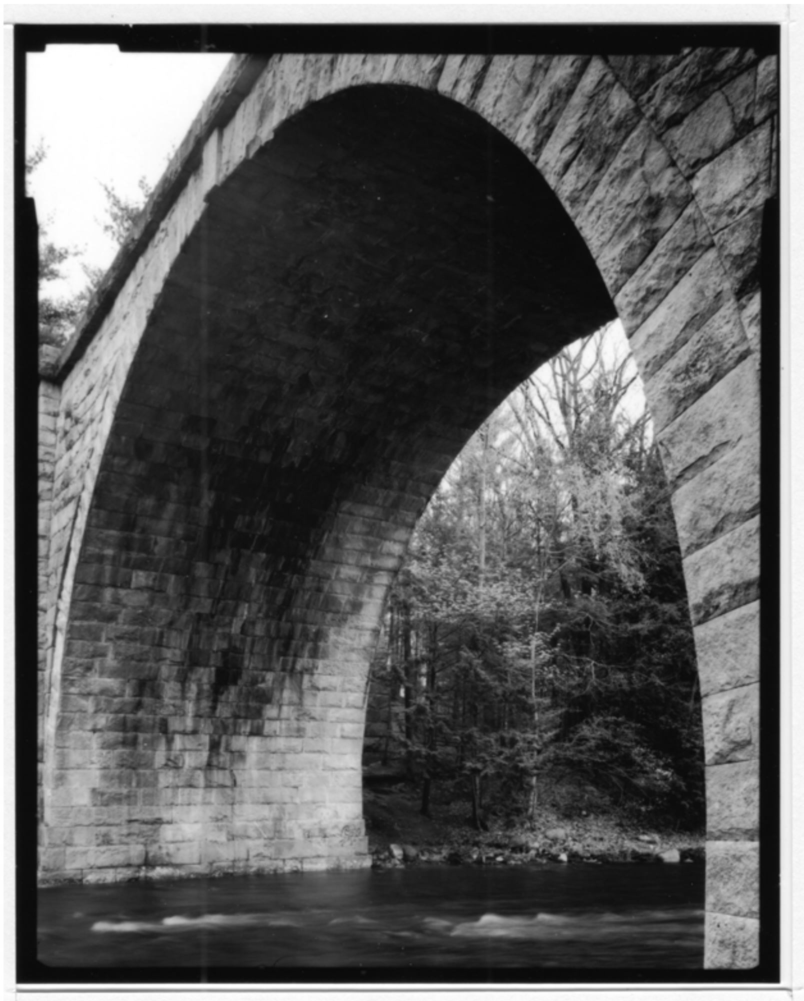


NH-630-8 Southwest wingwall. Looking east.

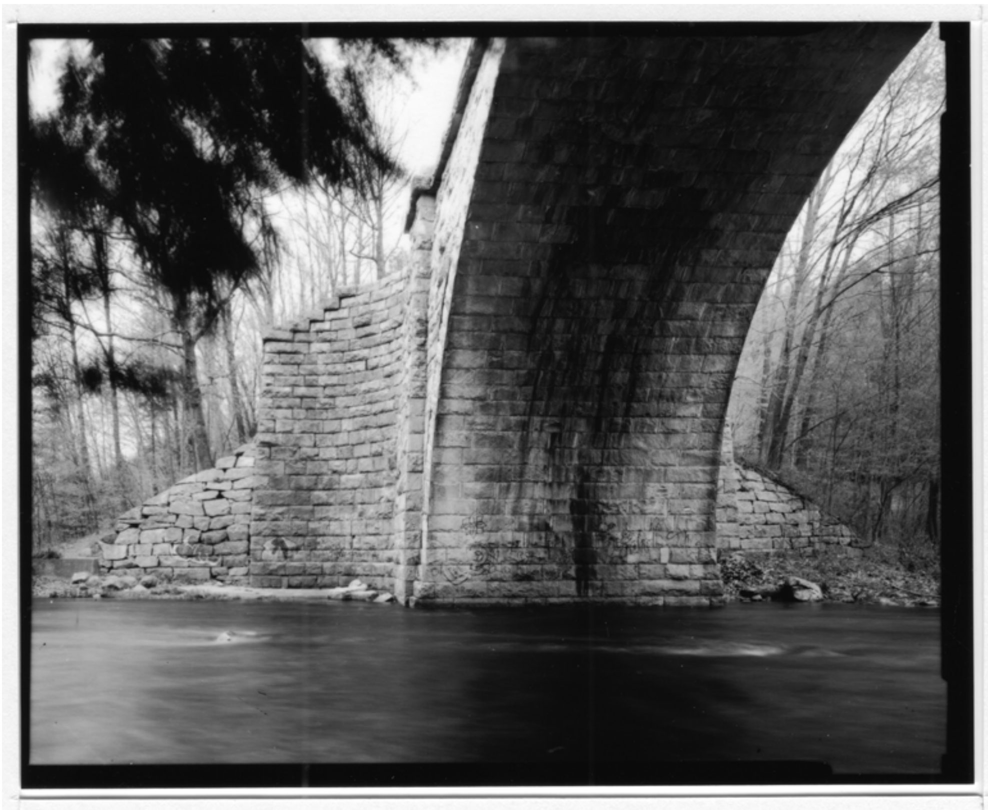
NH-630-9 Oblique view of arch and buttress from wingwall. Looking northeast.



NH-630-10 Arch soffit and wingwalls. Looking south.



NH-630-11 Arch soffit and wingwalls. Looking north.



NH-630-12 Former railbed, now trail, over bridge. Looking northwest.

NH-630-13 Detail of arch and buttress stonework. Looking southwest.