NEW HAMPSHIRE DIVISION OF HISTORICAL RESOURCES
State of New Hampshire, Department of Cultural Resources 603-271-3483
19 Pillsbury Street, P. O. Box 2043, Concord NH 03302-2043 603-271-3558
Voice/TTY RELAY ACCESS 1-800-735-2964 FAX 603-271-3433
http://www.state.nh.us/nhdhr *preservation@nhdhr.state.nh.us*

CENTRAL STREET (CENTER) BRIDGE
BRIDGE NO. 113/064
BRISTOL-NEW HAMPTON, NEW HAMPSHIRE

JAMES L. GARVIN
ARCHITECTURAL HISTORIAN
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Summary: The Central Street Bridge, connecting the towns of Bristol and New Hampton, New Hampshire, is the longest high Parker truss bridge built in New Hampshire to repair losses caused by the devastating flood of 1927, the first of three great floods that badly damaged New Hampshire's transportation system in the twentieth century.

The Central Street Bridge is an example of a classic highway bridge of the early twentieth century. It is notable for its Parker truss design and for its span of 240 feet. Often employed for medium- to long-span highway bridges during the first half of the century, the Parker truss was further refined in northern New England after the flood of 1927 to take advantage of available products of steel rolling mills. The Central Street Bridge reflects these refinements.

Some bridges built to overcome the devastating losses of the flood of 1927 were constructed on standardized plans that had been pre-approved by the federal Bureau of Public Roads. Unlike these standardized post-flood bridges, the Central Street Bridge was specifically designed for its dramatic location by Harold Langley, a brilliant engineer who served as the principal bridge designer at the New Hampshire Highway Department during the 1920s and 1930s. Although Langley provided a custom design for the bridge, he employed standard specifications developed by the federal Bureau of Public Roads, the predecessor to the Federal Highway Administration, thus qualifying the bridge for federal bridge aid funding.

The Central Street Bridge was determined eligible for the National Register of Historic Places on December 16, 1987.

Historical Background: The floods of November 3 and 4, 1927, exceeded all previous flood records in northern New Hampshire, putting a tragic end to "one of the mildest and most wonderful fall seasons ever witnessed by the present generation." Rain levels totaling between five and ten inches fell in a twenty-four-hour period. The Connecticut River rose thirty feet at Hanover, New Hampshire. The Pemigewasset and its tributaries rose swiftly, driving all the inhabitants of Beebe River Village in Campton to neighboring towns for safety, inundating the first and second stories of the buildings on Plymouth's Main Street, and isolating Plymouth village from outside contact.[1]

At Bristol, the waters were somewhat controlled by the Ambursen-type (buttress) hydroelectric dam that had been built upstream from the village in 1923-4.[2] Nevertheless, floodwaters damaged the Central Bridge, a two-span wooden covered bridge with laminated wooden arches, which dated from 1836 and stood about a mile downstream from the dam. The weakened span was washed downstream by high waters in the spring of 1928.[3]

Damage to roads and bridges in New Hampshire from the flood of 1927 was estimated at $2.5 million. Division engineers for the New Hampshire Highway Department reported that the heavy rains were often followed by landslides, which "blocked several of the mountain streams with debris so that their customary channels were altered, this causing the streams to overflow their banks and in many areas [to] seek new stream beds along the highways and railroad lines." [4] Damage in Vermont, where the eastern slopes of the Green Mountains received especially heavy rainfall, was far greater than in New Hampshire.[5]

The Central Street crossing is the site of some of the earliest bridges over the Pemigewasset River in the Bristol area. Like many early New Hampshire spans, the first bridge at this crossing was a toll bridge built by a private corporation. The New Hampshire legislature incorporated "the Proprietors of Central Bridge" on December 17, 1812, reincorporating the organization on June 22, 1820 when the first company failed to construct a bridge.[6] In both incarnations, the company was authorized to charge tolls for passage over the bridge, and was required to build

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[1] "November Flood Damage to Highway System Greatest in History of State," *New Hampshire Highways* 5 (November 1927); "Some Characteristics of Northern New England's 1927 Flood," *New Hampshire Highways* 5 (December 1927).
[2] H. M. Nabstedt, "The Bristol Dam: An Important Water Power Development," *Granite Monthly* 55 (1923): 425-428. This hydroelectric plant is now called the Ayers Island Hydroelectric Project; *see* Federal Energy Regulatory Commission, *Draft Environmental Impact Statement, Relicensing the Ayers Island Hydroelectric Project in the Pemigewasset/Merrimack River Basin, FERC Project No. 2456-009* (Washington, D.C.: Federal Energy Regulatory Commission, October 1994).
[3] Pauline Swain Merrill, *New Hampton: A Brief History of the Town of New Hampton, New Hampshire* ([New Hampton:] New Hampton Historical Society, 1964).
[4] "November Flood Damage to Highway System Greatest in History of State," *New Hampshire Highways* 5 (November 1927); "Some Characteristics of Northern New England's 1927 Flood," *New Hampshire Highways* 5 (December 1927).
[5] Arthur Stone, *The Vermont of Today with Its Historical Background, Attractions and People* (New York, N.Y.: Lewis Historical Publishing Company, Inc., 1929, *passim*; Report of Advisory Committee of Engineers on Flood Control, *Journal of The House of the State of Vermont, Biennial Session* (Montpelier, Vt.: Capital City Press Printers, 1929).
[6] *Laws of New Hampshire, Vol. 8, Second Constitutional Period, 1811-1820* (Concord, N.H.: Evans Printing Co., 1920), pp. 185-186, 911-912.

any necessary roads leading to the bridge on the New Hampton side of the river in addition to such roads as the town might build in any case.

The first bridge completed by the Proprietors was opened in 1823. It was a stringer bridge without a roof, supported by two piers in the river.[7]

The Proprietors found it necessary to replace this first bridge in 1836-7. The second bridge, which stood for ninety years, was a two-span covered truss bridge with a single stone pier near the center of the river. The bridge had laminated wooden arches to supplement its trusses, but it is not known whether these were original or later additions. The bridge became toll-free when the commissioners of Belknap and Grafton Counties agreed to lay out a public highway across the span in 1861, paying the Proprietors $300 in damages for the loss of tolls.[8]

The Central Street crossing long posed challenges to its bridges. The 1904 *History of Bristol* tells us that "the [wooden] bridge [built in 1836] has been an expensive one to maintain, and large sums have been expended on it from time to time. About 1854, the eastern [New Hampton] abutment was swept away by a flood of water, turned in that direction by a log jam at the [central] pier; while the bridge, itself, has several times narrowly escaped destruction by freshets. In 1870, Bristol rebuilt the western abutment and raised the western end of the bridge a few feet, at a cost of $1,355."[9]

Although the eastern (New Hampton) abutment was again replaced when the present bridge was erected in 1928, the new eastern seat of the current bridge remains at a lower elevation than the Bristol end.

Engineering background: The Central Street Bridge is the longest high Parker truss bridge built in New Hampshire as a result of the losses occasioned by the flood of 1927. The bridge was built as a single span, allowing the removal of the stone pier that had supported the center of the earlier covered bridge and offering the river unimpeded flow beneath the bridge.

The Parker truss is a variation of the Pratt truss. The Pratt truss and its variations emerged during the late nineteenth century as the favored designs for metal truss bridges. The Pratt truss and its descendants are characterized by vertical truss members, or posts, that define the panels of the trusses and act in compression. Extending diagonally across each panel is a tie, or tension member, which connects the upper chord of the truss to the lower, inclining toward the center of the truss. Patented in 1844 by Thomas W. and Caleb Pratt, this truss was sometimes employed in wood-and-iron covered bridge trusses, utilizing wooden posts and iron ties.[10]

The Pratt truss proved especially well adapted to all-metal bridge trusses, and before the introduction of structural steel in the late 1800s was often employed with cast iron posts and

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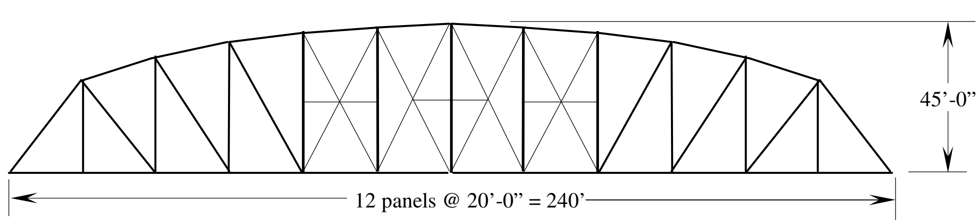
[7] Richard W. Musgrove, *History of the Town of Bristol, New Hampshire*, reprint of the 1904 ed. (Somersworth, N.H.: New Hampshire Publishing Company, 1976), p. 110.
[8] *Ibid*., pp. 112-113.
[9] *Ibid*., p. 113.
[10] Robert Fletcher and J. P. Snow, "History of the Development of Wooden Bridges" (1932), reprinted in American Society of Civil Engineers, *American Wooden Bridges* (New York: American Society of Civil Engineers, 1976), 62-63.

wrought iron ties. The introduction of Bessemer steel in the United States in the 1890s strengthened the favored status of the Pratt truss, which proved adaptable both to pin-connected and riveted spans for both railroad and highway work. The straightforward connections of the chords, posts and ties at each panel point made the Pratt truss easily susceptible to structural analysis by either the graphic or the mathematical methods that had been developed by 1850. Structural analysis permitted the stresses in each member to be calculated easily and accurately under various conditions of loading, and the introduction of high-strength steel at the very end of the nineteenth century permitted these stresses to be accommodated by light members. Short-span Pratt highway bridges of the late 1800s and early 1900s, designed for modest horse-drawn loads, are often exceedingly delicate in appearance.

The original form of the Pratt truss has horizontal upper and lower chords, with the upper chords in compression and the lower chords in tension. As bridge spans and weight limits increased during the late 1800s, the compressive stresses in the upper chords of Pratt trusses increased markedly toward the centers of the spans. These compressive stresses can be rendered more equal in both the chords and the web members by designing the upper chords on a curve that approximates that of a parabola, with the heights of the truss panels increasing toward to center of the span.[11]

The variation of the Pratt truss with a curved upper chord is called a Parker truss. Parker trusses became increasingly popular in railroad design after 1890, and began to appear in highway bridges as automobiles and motor trucks became factors in bridge design during the first decade of the twentieth century. Most moderate- to long-span highway bridges built in New Hampshire during the 1920s and 1930s adopted the Parker truss design.

As Parker trusses were employed in ever-longer spans, the length of their posts (the vertical compression members) became excessive. In such bridges, the extreme height of the posts toward the center of the bridge (as much as forty-five feet in the case of the Central Street Bridge) requires the insertion of horizontal stiffening members at the midpoints of the post height. These members play no part in the structural analysis of the span, but serve to prevent flexure or buckling of the principal compression members of the truss without requiring these members to be made excessively heavy.[12]



The evolution of the Pratt truss into the Parker truss combined several features that are desirable in a long-span bridge. First, as in the original Pratt truss, the principal stresses in each structural member remain axial. Second, in the Parker truss the stresses along various segments of the

[11] Mansfield Merriman and Henry S. Jacoby, *A Text-Book on Roofs and Bridges. Part I. Stresses in Simple Trusses,* sixth ed. (New York: John Wiley and Sons, 1908), 208-224; Ibid., *Part III. Bridge Design*, fourth ed. (New York: John Wiley and Sons, 1902), 310;
[12] Ibid., 223.

upper chord are kept relatively equal through the curved configuration of the chord. Third, the Parker truss proved to be an economical design, as measured by the cost per pound of the bridge.[13] These features ensured the widespread adoption of the Parker truss for spans exceeding 200 or 250 feet. By 1904, one American Parker truss had been built with a span that exceeded 400 feet.[14]

The Central Street Bridge was built as a direct result of severe floods that affected Vermont and northwestern New Hampshire in November, 1927. Technologically, the bridge is a reflection of the New Hampshire Highway Department's reaction to the devastating losses caused by these floods, and is an excellent example of long-span truss bridge design and construction in the 1920s. The Central Street Bridge is the longest Parker truss span built by the New Hampshire Highway Department as a result of the 1927 floods.

Damage from the flood of 1927 demanded the rapid construction of many steel bridges. Many of the short-span bridges washed out by the floods of 1927 were replaced by concrete bridges and culverts, and by plate girder spans measuring up to a hundred feet in length.[15] But the most dramatic of the flood replacement bridges were the high or "through" steel trusses that replaced long-span bridges lost to high water. These longer crossings were spanned by truss bridges of various designs. Among those constructed in direct response to flood damage were the following: a 120-foot Pratt through truss (Apthorp Bridge) over the Ammonoosuc River in Littleton; a 136-foot Pratt through truss at Bridge Street in Littleton; a 153-foot Pratt through truss at Twin Mountain in Carroll; a 136-foot Pratt through truss (Pierce Bridge) at Bethlehem Junction; a 136-foot Pratt through truss at Gorham; a 120-foot Pratt through truss at Jefferson; a 139-foot Pratt through truss at Lead Mine in Shelburne; a 120-foot through Warren truss at Bath; a 108-foot through Warren truss on Wing Road in Bethlehem; a 120-foot through Warren truss at Bethlehem Hollow; and a 108-foot through Warren truss at Wentworth.[16]

As noted above, the 240-foot Central Street Bridge was the longest flood emergency Parker truss bridge constructed after the flood of 1927. Other Parker through truss bridges built after the flood included a 220-foot bridge at Chiswick Avenue or Beacon Street in Littleton and a 220-foot bridge over the Connecticut River between West Stewartstown, New Hampshire, and Canaan, Vermont. Both have been replaced.

It is significant that the Parker truss bridges in Littleton (220/056) and Stewartstown (028/146) used the same shop details. Both bridges were designed to span 220'-0" between pins. Like several of the shorter Warren and Pratt truss spans listed above and sharing the same span lengths, these Parker truss spans were built using standardized plans to avoid needless custom designing of bridges under emergency conditions. Such bridges were generally placed on the existing abutments of their flood-damaged predecessors, but the bridge seats were adjusted to provide for the standardized pin-to-pin distances, thereby avoiding the need to design and fabricate different truss designs for minor variations in abutment spacing.

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[13] Mansfield Merriman and Henry S. Jacoby, *A Text-Book on Roofs and Bridges. Part I. Stresses in Simple Trusses,* sixth ed. (New York: John Wiley and Sons, 1908), 237-238.
[14] Ibid., 226-227.
[15] *New Hampshire Highways* 6 (August and September 1928).
[16] Ibid.

By contrast, the Central Street Bridge was designed for its specific site and circumstances by engineer Harold Langley. Langley joined the staff of the New Hampshire Highway Department in the early 1920s. At that period and until World War II, the Highway Department designed most of New Hampshire's bridges with its own highly skilled personnel, employing consulting engineers only on large and complex projects.

Langley quickly became one of the agency's most skilful and versatile bridge designers. He designed scores, if not hundreds, of bridges in both concrete and steel. He was a pioneer in the development of concrete rigid frames, continuous steel girder bridges, and other types of statically indeterminate bridge types, and was a noted expert on long-span structures.

At about the same time that Langley designed the Central Street Bridge and other "flood" bridges in Bethlehem and Littleton, he was also becoming proficient in the design of reinforced concrete bridges. Making a careful study of the delicate and beautiful concrete arches being built after 1927 by the Luten Bridge Company, which maintained an office in Concord, Langley emulated the grace and delicacy of the thin-shelled Luten arches. In 1927, he designed an 86-foot filled-spandrel concrete arch over the Mad River in Campton, followed by a similar arch in Colebrook in 1929. Langley and his colleagues designed a number of comparable concrete arches in the following years. In 1930, Langley designed the Vilas Bridge, a beautiful open-spandrel concrete rib arch bridge over the Connecticut River between Walpole and Bellows Falls.

Langley also pioneered in the introduction of the concrete rigid frame in New Hampshire, corresponding with Arthur G. Hayden, who introduced the rigid frame in the United States in several bridges he designed in the early 1920s in Westchester County, New York. By 1933, the New Hampshire Highway Department joined fifteen other state highway agencies in adopting the concrete rigid frame as a standard bridge design.

Langley also developed unusual skill in the design of steel bridges, both standard truss designs like the Central Street Bridge and more unusual structures such as steel arches. In 1930, Langley designed the 133-foot Beecher Falls Road Bridge over the Connecticut River at a new crossing between Stewartstown, New Hampshire, and Beecher Falls, Vermont. Langley's design was a deck span supported by a steel rib arch. This bridge received an award as the Most Beautiful Steel Bridge of 1931 from the American Institute of Steel Construction.[17] Building upon his experience, Langley superintended the design, by colleague John H. Wells, of the prize-winning steel rib arch bridges across the Connecticut River at Chesterfield-Brattleboro (1937) and Orford-Fairlee (1938).

Langley continued his pioneering efforts through the 1930s and after, leading New Hampshire to become one of the earliest states to utilize statically indeterminate continuous girder bridges. Langley's work earned him a national reputation, and in 1943 he co-authored the second edition of Hool and Kinne's *Movable and Long-Span Steel Bridges* (first edition, 1923), contributing a new section on steel arches.

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[17] *Engineering News-Record* 1932:870.

Most of the new Parker truss spans built in response to the flood of 1927 incorporated standard specifications issued by the federal Bureau of Public Roads. Like comparable bridges built in Vermont, the high or “through” truss bridges built in New Hampshire after the floods of 1927 differed from older spans primarily in employing an increased number of rolled steel I sections in their construction. Such bridges had fewer members built up of smaller rolled angle sections linked together by riveted lacing than had older bridges, reducing the time and hence the cost of fabrication.[18]

An article by engineer John W. Childs in *New Hampshire Highways* magazine in 1929 summed up the standards to which major bridges of this period were designed. All bridges were designed to carry a fifteen-ton truck in each line of traffic. Because trunk line highways were being plowed in the winter by this time, major bridges were designed with roadway widths of at least twenty-four feet. This gave two ten-foot traffic lanes and two two-foot margins for drainage and for plowed snow.[19] Perhaps because it was primarily a local connector built on an existing alignment, the Central Street Bridge is narrower, measuring eighteen feet from curb to curb.

The new Central Street Bridge was constructed with no encumbering pier in the river, permitting the greatest degree of undisturbed water flow beneath the structure. Yet fifteen years after construction of the bridge, a project downstream was destined to place the structure in an unusual relationship to the Pemigewasset River.

New Hampshire suffered again from widespread flooding in the spring of 1936. Damage from this series of floods was still greater in New Hampshire than the destruction of 1927. In response to these two disasters, occurring so close together, New Hampshire Senator Henry W. Keyes requested flood control assistance from the federal government. The result of Keyes’ plea, together with the urging of many others, was passage of the federal Flood Control Act of 1936 (Public Law No. 738, 74th Congress). Under this act, New Hampshire and other states were “required to provide, without cost to the federal government, all lands, easements, and rights-of-way; to hold and save the United States free from damages due to the construction works; to maintain and operate the works after completion; and to provide tax reimbursements to affected towns."

After passage of the federal law, the states of New Hampshire and Massachusetts entered into a compact to control flooding in the Merrimack basin. A law passed by the New Hampshire legislature in June, 1937, amended an earlier law that had created the Water Resources Board, declaring “a special public need for dams and reservoirs at strategic locations for regulating the flow of rivers and streams to lessen damages resulting from floods.”[20]

Two other laws passed in the same legislative session created the Merrimack River Valley Flood Control Commission, empowered the Water Resources Board to acquire lands necessary for flood control dams and reservoirs in cooperation with the Flood Control Commission, and

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[18] Historic Resource Consultants, Hartford, Conn., “Vermont Historic Bridge Survey, Final Report and Preservation Plan” (draft, 1985), pp. II:21-24.
[19] John W. Childs, “State Highway Bridge Program 1929,” *New Hampshire Highways* 7 (December 1929): 4.
[20] Chapter 118, Laws of 1937, “An Act Relative to the New Hampshire Water Resources Board.”

ratified the compact that had been agreed to between the State of New Hampshire and the Commonwealth of Massachusetts to carry out flood control measures in the Merrimack Valley.[21]

The first two projects specified under the compact and the state enabling legislation were flood control dams at Swett's Mills, on the Blackwater River in the town of Webster, and at Franklin, on the Pemigewasset River. The latter dam was to control

> a drainage area of approximately one thousand (1,000) square miles, and providing for flood control storage for approximately three and nineteen hundredths (3.19) inches of run-off over said drainage area, the dam at said reservoir to be constructed in such manner as to provide for flood control and in addition thereto to be so designed and constructed as to make it available for conservation or recreational purposes up to fifty percent of the volume during such portions of the year as may be approved by the secretary of war.[22]

Before construction began, the federal law was amended. The federal Flood Control Act of 1938 (Public Law No. 761, 75th Congress) specified that the flood control projects to be constructed under interstate compacts would be built entirely at the expense of the federal government and would thereafter be federally owned and operated. In 1939, New Hampshire passed a revised law that concurred with federal construction, ownership, and operation of flood control projects.[23]

The U.S. Army Corps of Engineers began construction of five flood control dams and reservoirs, including the Franklin Falls project, between August 1939 and June 1940, completing the Franklin Falls Dam in 1943.[24]

The impoundment from the Franklin Falls dam extends up the Pemigewasset River some thirteen miles, to the base of the dam at the Ayres Island hydroelectric station in Bristol. The Ayres Island dam is upstream from the Central Street Bridge. Thus, when the Franklin Falls Reservoir is filled to capacity, stored water rises some five feet above the deck of the Central Street Bridge at its eastern end, which, as noted above, stands at a lower elevation than the western end. The same phenomenon occurs at the Ramsdell Road Bridge (123/106) in Henniker, which stands upstream from the Everett Dam in West Hopkinton. The highway approaches to both bridges are gated and can be closed to traffic when water is to be stored to reservoir capacity.

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[21] Chapter 139, Laws of 1937, "An Act to provide for Co-Operation by the State with the Merrimack River Valley Flood Control Commission in the Acquisition of Lands, Easements and Rights of Way Essential for Flood Control Purposes, and to enable the State to Comply with the Provisions of the Compact entered into by it with the Commonwealth of Massachusetts and for Other Purposes;" and Chapter 142, Laws of 1937, "An Act Ratifying a Proposed Agreement between the State of New Hampshire and the Commonwealth of Massachusetts, relating to the Creation of the Merrimack River Valley Flood Control Commission, providing for Flood Control min the Merrimack River Basin and for Carrying Out the Provisions of said Agreement or Compact."

[22] Chapter 142, Laws of 1937.

[23] Chapter 149, Laws of 1939, "An Act Consenting to the Acquisition of Land by the United States for Flood Control and Navigation Purposes."

[24] U. S. Army Corps of Engineers, New England Division, *Water Resources Development, New Hampshire: The Work of the U. S. Army Corps of Engineers in New Hampshire,* NEDEP-360-1-35 (November 1995), pp. 34-35; Kathleen A. Atwood, area form for Blackwater Dam, Webster, N.H., on file at the New Hampshire Division of Historical Resources.

The Central Street Bridge is a significant engineering landmark that stands in a historic, picturesque, and environmentally challenging location. Future treatment of the bridge should consider the history, aesthetics, and constraints of the span and its site, the transportation needs of the two towns that share the crossing, and the unique hydrological conditions created by the Ayers Island Hydroelectric Project upstream, and the Franklin Falls Flood Control Dam downstream.