100th Anniversary Series Part II

High Water:

Rebuilding bridges after the floods of 1927 and 1936

By James Garvin, New Hampshire Division of Historical Resources

The engineering skills of the New Hampshire Highway Department were severely tested in 1927 and 1936, when devastating floods washed away miles of highway and railroad, as well as many bridges that traversed the state's primary rivers and their tributaries. Part II of the New Hampshire Highways 100th Anniversary Series describes the devastation wrought by flood waters, and focuses primarily upon bridge construction and reconstruction following these floods.

The flood of 1927

In early November 1927, much of northern New England experienced the heaviest rains in memory. Between five and ten inches of rain fell in a twenty-four-hour period in parts of New Hampshire and Vermont, sending the Connecticut, Merrimack, Androscoggin and Saco Rivers, and their tributaries, into flood stage. The Connecticut River rose thirty feet at Hanover during the night of November 3. Water covered the second stories of buildings along Plymouth's main street; Claremont's streets were under twenty feet of water. Great numbers of bridges were carried away, wooden bridges sometimes floating downstream to break against metal spans. Miles of highway and railroad were destroyed.

Rebuilding bridges: 1928

The New Hampshire legislature authorized the governor to spend up to three million dollars in repairing flood damage. In a departure from the traditional state-aid system, municipalities were not asked to provide any matching funds for state expenditures under the flood repair program. Bridge and highway work began during the winter and continued through 1928.

Among the more common types of bridges built after the flood of 1927 were short concrete arched spans. Another common type of concrete structure introduced in some numbers after the flood was the T-beam bridge, ranging in span from about twelve to sixty-five feet. The New Hampshire highway department also built a number of short-span concrete rigid frame bridges after the flood. Rigid frame bridges achieved great popularity in the following decade.

Also widely used in flood repairs were plate girder bridges-spans in which the bridge structure is composed of deep, built-up steel girders that support floor framing for the road. At least nine such bridges were built in northern New Hampshire in 1928.

The most dramatic of the flood replacement bridges, however, were the high or "through" steel trusses that replaced long-span bridges lost to high water. Among the new bridges erected in 1928 were a 120-foot Pratt truss (Apthorp Bridge) and a 126-foot Pratt truss over the Ammonoosuc River in Littleton; a 153-foot Pratt truss at Twin Mountain in Carroll; a 136-foot Pratt truss (Pierce Bridge) at Bethlehem Junction; a 136-foot Pratt truss at Gorham; a 120-foot Pratt truss at Jefferson; and a 139-foot Pratt truss at Lead Mine in Shelburne. The same campaign saw the construction of single-span Parker truss bridges in Bristol (over the Pemigewasset River), Littleton (over the Ammonoosuc River), and Stewartstown (over the Connecticut River); single-span Warren trusses in Bath, Bethlehem, and Sugar Hill; and a three-span Pratt deck truss bridge over the Connecticut River at Dalton. One of the most dramatic of the "flood" bridges is a 352-foot Pennsylvania truss span over the Connecticut River from Piermont to Bradford, Vermont. Harold E. Langley of the New Hampshire Highway Department designed, or supervised the design, of most of these bridges.

Most of the new high truss spans incorporated standard specifications issued by the federal Bureau of Public Roads. The American Bridge Company of Pennsylvania constructed several of these spans under contract with the New Hampshire Highway Department. The American Bridge Company was working closely with the Vermont Highway Commission in designing bridges west of the Connecticut River after the flood. New Hampshire's post-flood through trusses therefore closely resemble standard designs being constructed in even greater numbers in Vermont at the same time. Like the Vermont bridges, the high or "through" trusses built in New Hampshire differed from older spans mostly in employing an increased number of rolled steel sections in their construction and fewer built-up members.

The flood of 1936

The unprecedented rainfall of 1927 was the kind of event called a "hundred-year" flood – rainfall of a magnitude that occurs, on average, only once in a century. Recognizing this, a writer in New Hampshire Highways magazine voiced the need for stream gauging stations at the extreme headwaters of New Hampshire's major rivers. "Before the next (2028) flood we may have them," the writer hoped.

PHOTO: *The rising Merrimack carried away several wooden railroad bridges during the 1927 flood, one of which is shown here, "beached" with other debris, in Hooksett.* New Hampshire Historical Society

Hookestt was one of the hardest hit communities during the floods of 1927 and 1936. This photo shows the destruction of the Main Street highway and railroad bridges after waters receded in March 1936. New Hampshire Historical Society

The next "hundred-year" flood did not wait until the year 2028. On March 12, 1936, four days of rain and warm weather freed a heavy blanket of snow and ice that covered northern New England. Smaller rivers like the Saco and the Pemigewasset were the first to flood, causing great damage along their lengths. Then, on March 18, the great rivers of the region broke free of the ice bonds that restrained them.

The Connecticut, Merrimack, and Androscoggin all surged out of their channels, filling their valleys not only with unprecedented volumes of water but with thick ice floes that destroyed everything they hit. Debris began to choke river channels, gathering against the floors and sides of innumerable bridges as surging water attacked their abutments and piers. Many new spans built after the flood of 1927 were crumpled by the impact of ice or by the pressure of water against lumber, buildings, or trees lodged against their sides.

State and federal assistance

By the time of the floods of 1936, the United States was in the middle of the Great Depression. The federal government had instituted several programs both to provide employment and to improve the nation's highways. Among the New Deal programs of the 1930s was the National Industrial Recovery Act of 1933, which provided $400 million for road projects without a requirement for financial match. Funds appropriated under this law could be used on "secondary and feeder roads," thereby improving many rural highways.

In the same year (1933), the New Hampshire legislature passed a law making the New Hampshire Highway Department fully responsible for all construction and maintenance on trunk line highways, including the bridges on those routes, except within the compact parts of cities and towns with populations over 2,500. The Hayden-Cartwright Road Act of 1934 provided another $200 million for highway projects, with a minimum of 25 percent to be expended on secondary and feeder roads.

Collectively, these laws provided for greatly increased federal and state oversight of road and bridge construction in all states. Title II of the National Industrial Recovery Act, for example, required that "all plans must be submitted to and approved by the [federal] Bureau of Public Roads before construction can commence and all work [shall be] carried out under state and [federal] Government supervision."

Rebuilding bridges: 1937

Federal emergency aid was essential in reconstructing the Connecticut River bridges after the 1936 flood. Several bridges erected in 1937 essentially duplicated designs that had proven themselves after the 1927 flood. The New Hampshire Highway Department built a single-span high Parker truss over the Connecticut between Monroe, New Hampshire and Barnet, Vermont, and a two-span high Parker truss between Lyme, New Hampshire, and Thetford, Vermont.

The Orford/Fairlee and Chesterfield/Brattleboro bridges

After the flood of 1936, the New Hampshire Highway Department faced the need to replace a wooden covered bridge between Orford, New Hampshire and Fairlee, Vermont, and an antiquated suspension bridge downstream between Chesterfield, New Hampshire and Brattleboro, Vermont. The wooden

bridge had been so damaged by the flood of 1936 that it had to be condemned and dynamited.

The task of designing two new arched spans across the Connecticut River was entrusted to New Hampshire Highway Department project engineer John H. Wells under the supervision of assistant bridge engineer Harold E. Langley. Wells's bridges are through arches, with the roadways at or near the feet of the arches, and are dramatic in their geometry. Their massive arches are silhouetted against the sky, juxtaposing their pure lines against the rugged hillsides that embrace them.

In solving the problem of spanning the Connecticut River in these two locations, Wells and Langley employed two-hinged arches. The distance between pins at both the Orford-Fairlee and Chesterfield-Brattleboro bridges is 425 feet. Both bridges have massive hollow ribs composed of box-like sections riveted together.

Because geology of the site permitted it, the abutments of the Chesterfield-Brattleboro bridge are anchored in the earth, which both supports the 1.5 million-pound weight of the bridge and resists the horizontal thrust of the arches. Because the sandy soil farther upstream cannot resist horizontal forces, Wells and Langley tied the two ends of the Orford-Fairlee bridge together like an archer's bow. The steel members that run beneath the road surface resist the horizontal thrust of the arches, leaving only the weight of the bridge to be supported by the abutments.

In 1937, the American Institute of Steel Construction awarded Wells's and Langley's Chesterfield-Brattleboro Bridge honors as the most beautiful bridge of its class built in the United States that year. Remarkably, the Orford-Fairlee Bridge won second prize. These dramatic designs of the New Hampshire Highway Department vied with the famous French King Bridge over the lower Connecticut River at Erving and Gill, Massachusetts, an arched deck span that had won first-place honors in its class in 1932. Harold Langley described and illustrated both of the New Hampshire bridges in his 1943 revision of Hool and Kinne's Movable and Long-Span Steel Bridges.

The Orford-Fairlee Bridge was thoroughly rehabilitated in 2002-2003. At the same time, the Chesterfield-Brattleboro Bridge was bypassed by a wider arched bridge of similar design in an unusual tribute to the award-winning earlier structure. The older bridge will eventually be refurbished for local and recreational traffic.

This photo of the McGregor Bridge in Manchester was taken as the span began to break up during the floods of 1936. As debris from this bridge was swept downstream, the Amoskeag Steam Pipe Bridge was also destroyed.

The Notre Dame Bridge

The floods of 1936 claimed a noteworthy structure on the Merrimack River. This was the McGregor Bridge at Bridge Street, connecting the east and west millyards of the Amoskeag Manufacturing Company. This three-span lenticular truss bridge had been built in 1880 by the Corrugated Metal Company of East Berlin, Connecticut (predecessor to the Berlin Iron Bridge Company) at the unprecedented cost of $67,000.

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One of the most dramatic bridges constructed after the 1927 flood was the 352-foot Pennsylvania truss span over the Connecticut River from Piermont to Bradford, Vermont, completed in 1929.

The span was unusual not only in its total length of 930 feet, but also in having two decks, the upper deck serving general traffic and the lower deck reserved for mill employees traveling to and from their work.

Despite the economic depression that engulfed Manchester when the Amoskeag Manufacturing Company announced its closing in 1936, the city replaced the lost bridge with a remarkable new span.

The Notre Dame Bridge, as it was named, was a monumental trussed steel arch carrying a suspended roadway. The arched span was approached by an extended causeway that lifted the entire highway fifty-two feet above normal water level and twenty feet above the high water mark of 1936. Construction was funded jointly by the federal Bureau of Public Roads, the Works Progress Administration, the State of New Hampshire, and the City of Manchester.

The causeways that led to the steel span were supported by eleven reinforced concrete rib arched spans (nine on the east side of the river and two on the west) designed to permit future flood waters to pass harmlessly through their piers. The steel arch was designed by the J.R. Worcester Company of Boston, whose founder had designed what was then the longest arched bridge in the United States over the Connecticut River at Bellows Falls in 1905. Like the Bellows Falls Bridge, the Notre Dame Bridge was a statically determinate three-hinged arch. The arch measured 444 feet between pins, and rose to an apex 130 feet above the water. The truss alone contained two million pounds of steel.

After fifty years of service, the Notre Dame Bridge was demolished in 1989 and replaced by a wider, elevated bridge of welded steel stingers.

Controlling New Hampshire waters

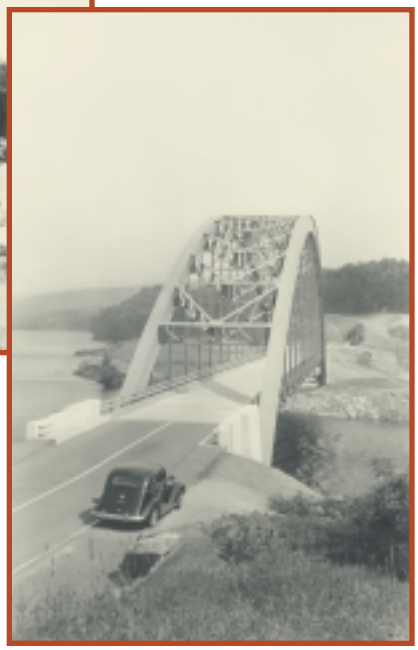
In June 1935, one year before the devastating flood of 1936, the New Hampshire legislature had created the Water Resources Board. The purpose of this Board, as stated in its charter, was to "make studies and plans and to construct such works as would improve the regulation and conditions of the natural water of the state, rendering these water resources more beneficial to the industries and communities located on their borders."

The two-span, 459-foot Parker truss bridge between Lyme and Thetford, Vermont was completed in 1937.

After the flood of 1936, the Water Resources Board was charged with the task of addressing and solving the "flood problem" in New Hampshire. The Water Resources Board, with assistance from the US Army Corps of Engineers, planned and constructed a flood control system that now controls storm and winter runoff, and alleviates the threat of damaging floods downstream.

The system of dams and reservoirs constructed over the next several years, controls the flow from the five major rivers in the state – the Androscoggin, Saco, Piscataqua, Merrimack, and Connecticut. Depending upon the rate at which water rises, different combinations of these dams can be opened and closed to prevent the watershed areas downstream from being inundated.

Editor's Note: Special thanks to Patricia Skoglund for sharing with us her Uncle Edward W. Healy's copy of the book *Flood Waters – 1936.* The book was published after the floods of 1936 by Lew Cummings, and is a pictorial review of flood damage around the state. The book is available at the New Hampshire Historical Society and the New Hampshire State Library.



The Chesterfield-Brattleboro Bridge, shown here under construction, and soon after completion, received top honors from the American Institute of Steel Construction in 1937 as the "most beautiful bridge of its class built in the United States that year."