Figure 1 - Existing Structure - 1997

Figure 2 – Rehabilitated Structure - 2007

The Narrows Bridge – *Preserving History*

By: Rodney Miller, P.E., Glenn Seibert, P.E., and Jason Reisinger, P.E.

The U.S. Route 30 Narrows Bridge was recently rehabilitated by the Pennsylvania Department of Transportation (PennDOT), District 9-0. The project was part of the 4.7 mile, $67.7 million U.S. Route 30 Transportation Improvement Project in Bedford County, Pa. The Narrows Bridge is the focal point of the project and carries Route 30 over the Raystown Branch of the Juniata River just south of the Pennsylvania Turnpike. The existing open-spandrel, concrete arch bridge was constructed in 1935. In 1997, it was listed on the National Register of Historic Places and also declared a part of the Lincoln Highway Heritage Corridor. As such, one of the primary goals of the project was to preserve and replicate both the function and the architecture of the main structural elements of the arch bridge. PennDOT and its design team worked closely with the Pennsylvania Historic and Museum Commission to produce the desired appearance, as shown in Figures 1 and 2.

Early History

In the Historic American Engineering Record Report No. PA-449, writer Blythe Semmer, provides a detailed account of the notable events at the site with references to several local historians. She notes that the existing arch structure is actually the sixth bridge at the location. Starting in 1806, and for the entire century that followed, the crossing was under the control of the Chambersburg-Bedford Turnpike Company. This company was one of 10 private groups that was charged by the Pennsylvania General Assembly to construct and operate a road from Harrisburg, PA., to Pittsburgh, PA. Known as the Pennsylvania Road, it was completed in 1818 and carried 90 percent of all east/west commerce in the United States until the completion of the Erie Canal in the fall of 1825.

There were five bridges at the Narrows site prior to the 1935 construction. The first four were all wooden structures and were destroyed by various accidents, fires, and vandalism. The fifth structure was made of steel and was replaced when the alignment of the Lincoln Highway was shifted slightly for the 1935 reconstruction.

Like most of the other early highways, canals, and railroads, the Pennsylvania Road, was built and operated by a private company. This philosophy lasted until the era of big government began in the 1920's when the states took control of many private facilities and highways. It was in 1929 that the Pennsylvania Department of Highways assumed control of the Pennsylvania Road and was the actual design engineer for the concrete arch structure. Ironically, it is interesting to note that there is currently a trend back to private operation of some tolls roads and transit systems through public-private partnerships, which is similar to the philosophy that was in place nearly 200 years ago.

The Design of 1935

The original open-spandrel, concrete arch bridge was built in 1935 by the Pittsburgh Bridge Company and was designed by the engineers of the Pennsylvania Department of Highways. The challenges were many, from both a design and a construction perspective. The alignment was curved to match the topography and the piers were sharply skewed and set parallel to the flow of the Juniata River. The obvious structure configuration was to curve the roadway, chord the arch ribs, and skew the piers at 42 degrees. There is some question as to the selection of an open-spandrel arch structure as the most appropriate type, given the complex geometry at the site. There was speculation at the time that this was the only bridge of this particular arrangement in existence at the time of construction and, a guess might be that the uniqueness may have driven the selection of the bridge type. If conceived today, this type of continuous arch structure would have the designer running to the computer looking for the Structural Analysis and Design (STAAD) program. In fact, STAAD was the main tool used for the current rehabilitation design. Unfortunately, no such tools existed in the 1935 time

frame. However, during that era there were other methods available to the designers. Both approximate and exact methods of analysis existed at the time to assist in the design of arch type structures. Classical methods developed by J. Melan, D. B. Steinman, S. P. Timoshenko, and others, provided acceptable results for proportioning arch and other frame type structures.

Also of interest, were the difference in the rules and regulations and other factors that influenced the selection of the structure type at this early time. The previous steel structure was not historic, so there was no attempt or desire to mimic existing functions or architectural themes. Labor costs were cheap, so in 1935, cast-in-place concrete with wooden forming was the construction material of choice for many bridges in the rural areas. Protection and preservation of natural habitats at the site was not a primary focus and, as such, did not influence either structure configuration or construction methods. This can be seen quite vividly when comparing the photo (Figure 3) of the 1935 construction, where the river was used as a dumping site for excess and unused materials, with a photo (Figure 4) of the more recent activities showing a much cleaner operation.

Figure 3 – Original Construction – 1935 (Photo courtesy of HAER)

Figure 4 – New Construction: 2006

Rehabilitation Design

The current work, which was completed in 2006, included the rehabilitation of the existing arch ribs and foundations and the replacement of the spandrel columns, floorbeams and the bridge deck. Special efforts were made by the design team to produce a finished product that closely matched the appearance of the original historic structure.

Although the Narrows Bridge project provides an example what can be achieved in the replication and preservation of an historic landmark, a comparison to a more current structure type, driven by today's design codes and construction techniques and materials, can be seen directly beside the arch structure. The overall project highway design required an increase in traffic capacity at the bridge site. Accordingly, in addition to the rehabilitation of the existing arch structure, an additional two-lane bridge was required to handle the traffic demand. This new structure is a typical modern PennDOT design that includes slender hammerhead piers supporting prestressed, concrete I-beams and a concrete deck.

Rehabilitation Construction

As noted above, the existing bridge consisted entirely of cast-in-place elements which included a concrete deck composite with the concrete-encased steel I-beams that acted as the transverse floorbeams. The construction was tedious with little duplication of dimensions. Given the curved, skewed, chorded configuration, all of the arches and columns were of different lengths and required unique forming, rebar lengths, etc. Of interest to today's bridge contractors and engineers, is the construction time required to build the 1935 version of the crossing. The surprise is that the structure, even with the complex configuration, was completed in one construction season. Of course, in the "old days", there were no arbitrary work stoppages or delays that hinder many current projects located in similar sensitive areas.

The rehabilitation work included the demolition of the existing bridge elements down to the arch ribs. The existing square rebar, that served as the connection between the arch and spandrel columns, was preserved and was supplemented by additional reinforcement that was drilled and grouted into the arches. After casting the new spandrel columns, precast concrete floorbeams were placed on the column tops. Neoprene bearings and restrainer brackets carried the vertical and horizontal loads and directed the movement of the superstructure. Precasting the floorbeams allowed the contractor to expedite construction by fabricating the floorbeams prior to taking the bridge out of service. Additionally, the design allowed the contractor to support the deck-finishing machine from the cantilevered ends of the floorbeams, thereby simplifying deck construction. Transverse restraint brackets, consisting of galvanized steel plates and angles, allowed longitudinal movement of the bridge deck, while transferring transverse forces into the spandrel columns and arch ribs. The contact surfaces of the transverse restraint brackets utilized PTFE (Teflon®) to accommodate the movements without transmitting longitudinal forces, while short slotted holes allowed the brackets to be turned after the deck pour, ensuring a uniform bearing surface. Longitudinal restraint brackets are located at the fixed pier columns and provide the longitudinal fixity of the superstructure.

Preserving History

One of the primary goals of the narrows Bridge project was to preserve and replicate both the function and the architecture of the main structural elements of the historic Narrows Bridge. Through a commitment to quality and attention to detail by all parties, these goals were achieved and a bit of history along the Lincoln Highway Heritage Corridor was preserved.

Rodney Miller, P.E., Glenn Seibert, P.E., and Jason Reisinger, P.E., of Gannett Fleming, Inc.

The Narrows Bridge is owned by the Pennsylvania Department of Transportation. Gannett Fleming was the Engineer of Record for the rehabilitation. New Enterprise Stone and Lime was the general contractor. The success of all three parties efforts are reflected in the recent awards bestowed on the project. The Narrows Bridge project won the 2008 Diamond Award from the American Council of Engineering Companies of Pennsylvania (ACEC-PA), the Globe Award in 2007 from the American Road and Transportation Builders Association (ARTBA), and the 2007 Susquehanna Chapter Award from the Susquehanna Chapter of the Association of Bridge Construction and Design (ABCD).