Germantown Avenue Bridge over Wissahickon Creek

Philadelphia

URS Corporation

The Germantown Avenue Bridge over Wissahickon Creek in Philadelphia is a three span curved steel girder bridge that was designed to safely replace a failing nine span straight bridge.

The location of the old bridge forced a hazardous curve, allowing a maximum speed of only 15 mph. In 1997, several undermined piers cracked and, after emergency repairs, vehicular traffic was restricted to one-way next to the downstream edge of the deck. Structurally, the bridge was rated "poor" even before the piers cracked. Collapse or removal of the sidewalk overhangs required the addition of traffic barriers that restricted roadway width and further reduced safe operating speed.

Owner
City of Philadelphia Department of Streets, Bridge Division

Engineer of Record
URS Corporation, Fort Washington, PA

Engineering Software
BSDI, ABUT5, BAR7, SEISAB

Detailer
Steelcon, Inc., Cordova, TN, AISC member, NISD member

Detailing Software
AutoCAD

Fabricator and Erector
High Steel Structures, Inc., NSBA/AISC member

General Contractor
Neshaminy Constructors, Inc., Feasterville, PA

A new, horizontally curved roadway alignment replaced the existing sharp bend to improve roadway safety. The resulting baseline radius of about 488' required the curved superstructure.

The 14,000 cfs flow of Wissahickon Creek was also severely constricted by this bridge's eight original stone piers, which created narrow hydraulic openings of approximately 18'. Upstream flooding occurred when one or more of the spans clogged with debris. Increased stream flow velocity in the remaining spans caused major scour beneath the foundations, which required periodic repairs.

The number of spans for the new bridge was limited to three to improve the stream flow underneath, and new abutments were placed beyond the existing abutments. The combination of the curved alignment and the positioning of the piers and abutments parallel to the stream caused skew angles as low as 50° between the bearing lines and baseline. A relatively shallow superstructure was proposed to keep the bridge above the 100-year storm water surface elevation.

A refined method of analysis was performed on the curved steel girders and radial positioned diaphragms to determine design forces. Initial results indicated very large diaphragm forces. Rather than proposing massive diaphragms, the engineers removed the diaphragms located closest to the piers and abutments. Re-analysis results indicated lower diaphragm forces while still providing adequate lateral bracing for the girder compression flanges.

Aesthetic Considerations

Two separate superstructures were designed for sidewalks. The upstream sidewalk and roadway lanes were placed on a constant width curved deck. The downstream sidewalk was located on a variable width chorded deck with a curved upstream edge to match the downstream edge of the vehicular deck for two of the three spans. The engineers were able to successfully design each structure, given the significant curved beam requirements, through the use of fabricated structural steel to support each deck.

The owners wanted a pedestrian superstructure deck that was durable, aesthetically pleasing, and capable of being quickly replaced if damaged. Wood planking over steel grid flooring met these requirements. The steel grid was easily attached to the supporting steel beams. The wood deck was assembled in panels and bolted to the steel grid, which allowed rapid partial replacement of deck areas if needed.

The owners also wanted building materials that would look pleasing but require minimal maintenance. All visible structural steel was protected with a three-coat epoxy paint system pigmented to match the surrounding green foliage. Non-visible structural steel was galvanized. All cast in place concrete was textured or stone-lined and pigmented.

Excessive lateral movement was detected when an external horizontal movement was introduced after erection of the steel girders for the pedestrian bridge. It was believed that the installation of the steel grid and wood deck would stabilize the structure, but methods to reduce the movement were also considered as a precaution. The designers suggested that a "soft-tie," similar to a steering strut on an automobile, be placed between the outside vehicular bridge steel girder and the inside pedestrian bridge steel girder. The intent was to provide lateral restraint to the pedestrian bridge without transmitting live load deflections or vibrations from the vehicular bridge into the pedestrian bridge. A detail using steel rods and fabric pad washers and bushings was developed. The concept was installed before the steel grid and wood deck were attached to the girders. After completion, the pedestrian bridge exhibited no perceptible lateral movement due to external force and no perceptible vibration during car or truck passage on the vehicular bridge.

The engineers elected to replicate the original bridge's railing. Although both of the original railings had been lost during failure of the sidewalks, the city had detailed drawings of them. These drawings enabled a copy for use on the new structure. A shorter railing was used on top of the shaped safety barriers to protect bicycle riders from falling.

Realignment of the roadway necessitated the removal of one of two driveways to a nearby college. The college requested that the remaining entrance be widened and improved with a new traffic signal. The wider entrance would allow construction of a future guard house between the incoming and outgoing lanes. The existing entrance was flanked by a 15'-long by 5'-wide by 6'-tall pilaster on each side. The engineers proposed that one of the pilasters be carefully disassembled and reconstructed to provide the wider entrance. However, after excavation around the pilaster was completed, it was decided to roll the entire pilaster into its proposed location. This was performed successfully and the architectural integrity of the structure was maintained.

The new roadway was designed for a 35 mph travel speed. Lane widths were reduced to only 11' to encourage slower travel speeds. Superelevation was limited to 2%, and shoulder and bikeway rumble strips confine motorists within the cartway. The bridge provides hydraulic openings of at least 75'. A separate, adjacent, downstream structure provides a wider, wood-decked pedestrian crossing. Use of real and formed stone surfaces on parapets, traffic barriers, and substructures helps integrate the bridge into its surroundings. ★