REHABILITATING MARYLAND ROUTE 195

(CARROLL AVENUE) BRIDGE OVER SLIGO CREEK

by Fred Braerman, Johnson, Mirmiran & Thompson, and Maurice Agostino, Maryland Department of Transportation, State Highway Administration

The Maryland Route 195 (Carroll Avenue) Bridge over Sligo Creek, located in the Washington, D.C., suburb of Takoma Park, Md., is a nonredundant, open-spandrel, reinforced concrete arch bridge that carries one lane of traffic in each direction, with sidewalks on both sides. Nearly 80 years after being constructed in 1932, the bridge became rated structurally deficient in 2011, when routine inspections found extensive and worsening deterioration of the bridge deck. While evaluating options for this aging structure, Maryland Department of Transportation (MDOT) officials recognized the functional and historic significance of the bridge and concluded that replacing it with a girder-type structure would not be the right solution. Instead, MDOT decided that rehabilitation was the appropriate strategy, a decision that was well received by the community. A construction contract was awarded to the prime contractor for $9.3 million in October 2015, and the project was completed less than one year after the bridge was closed to traffic. The bridge was reopened ahead of schedule in June 2017.

Planning and the Decision Process

Originally built with non-air-entrained concrete and black reinforcing steel, the 220-ft-long Carroll Avenue Bridge has span lengths of 65, 90, and 65 ft and traverses Sligo Creek Parkway, Sligo Creek, and a county-owned trail for hiking and biking. In 2011, the MDOT State Highway Administration (SHA) Office of Structures contracted the bridge design engineer to perform an in-depth field inspection, structural analysis, and assessment of the bridge. Because the bridge was eligible for inclusion on the Historic Register and on MDOT SHA's Priority 1 list for preservation, the bridge design engineer focused on rehabilitation strategies.

The bridge design engineer's findings indicated that replacement of all portions of the bridge above the arch ribs would be required to address the extensive deterioration of the deck, floor beams, columns, and spandrel arches. The plan was to repair and preserve the existing substructure units and arches while reconstructing the remainder of the bridge from the arch ribs up. The complete reconstruction of the bridge above the arch ribs would allow for the structure to be widened curb-to-curb by 2 ft, creating 11-ft-wide travel lanes. The community wanted wide shoulders to make biking safer in this residential area.

Additionally, the rehabilitation would include new sidewalks on both sides of the bridge, with new sections of sidewalk extending past the ends of the bridge to provide improved pedestrian access to all four approaches to the bridge.

During the planning stage, several project-specific challenges were noted. The bridge's location, 50 ft over a ravine within the floodplain of Sligo Creek, constrained the project site. Existing utilities on the bridge and adjacent overhead utilities on the west side of bridge would have to be temporarily relocated to allow for construction. Sligo Creek Parkway, located beneath the southernmost span, was a major commuter route within this congested suburb, and a heavily used hiker-biker trail located beneath the northernmost span would need to remain open during rehabilitation.

Project leaders conducted extensive public outreach to gain input and support from the community. For example, they held multiple public meetings and coordinated plans with Washington Adventist Hospital on the north side of the bridge, the Takoma Park City Council, the Montgomery County Transit bus system, Montgomery County Parks, and local emergency responders.

Design Challenges

When a bridge is rehabilitated, its geometry must be maintained. The existing Carroll Avenue Bridge was

profile

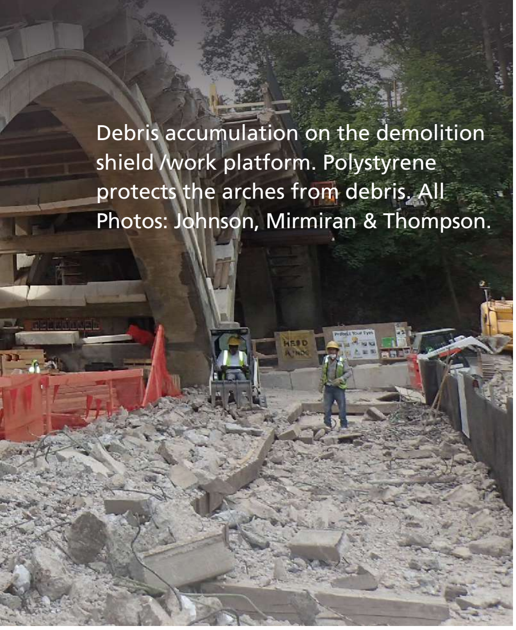
MARYLAND ROUTE 195 (CARROLL AVENUE) BRIDGE OVER SLIGO CREEK /
TAKOMA PARK, MARYLAND

BRIDGE DESIGN ENGINEER FOR REHABILITATION: Johnson, Mirmiran & Thompson, Hunt Valley, Md.

PRIME CONTRACTOR: Kiewit Infrastructure South, Omaha, Neb.

REINFORCING STEEL SUPPLIER: Gerdau, York, Pa.

OTHER CONSULTANTS (ROADWAY AND TRAFFIC DESIGN): Mercado Consultants Inc., Ashton, Md.; Sabra and Associates Inc., Columbia, Md.



Debris accumulation on the demolition shield /work platform. Polystyrene protects the arches from debris. All Photos: Johnson, Mirmiran & Thompson.

on the crest of a vertical curve, which resulted in a sump at each abutment just past the end of the bridge. The City of Takoma Park requested that drainage improvements be made to alleviate flooding from these sumps. During design, the bridge design engineer found that the existing sump inlets were severely undersized as the result of increased development over the years. The inlets were therefore replaced with larger, more efficient curb-opening-at-grade inlets to minimize the potential for flooding in the future.

Maintenance of traffic during reconstruction of the cast-in-place reinforced concrete bridge was a significant challenge. Unlike a typical redundant, multi-girder bridge arrangement, removing one of the two arches during a staged construction scheme would render the bridge unstable. After this inherent problem with the structure configuration was explained to the stakeholders, all parties agreed that closing the bridge during construction and detouring traffic was the only feasible construction solution. However, this decision presented a problem for pedestrians because there was no alternative way to safely cross the ravine on foot. Therefore, MDOT SHA required the contractor to provide a 295-ft-long temporary pedestrian bridge along the east side of Carroll Avenue.

A major structural concern involved maintaining a balanced-loading condition during the sequence of demolition and build back to avoid overstressing the existing arches that were to remain. The project leaders were especially mindful of this issue because three workers had died on this site in 1932, when a previous reinforced concrete bridge built in 1904 collapsed during demolition prior to construction of the arch bridge.[1,2] In the rehabilitation project, every precaution was taken to ensure safe conditions. The contract plans included requirements for a 22-stage systematic construction sequence working from the center of each arch outward in a concentric fashion about the crown of the arch. A structural analysis was performed using software under each condition of demolition and build back to verify that the arches were not overstressed during any of the stages.

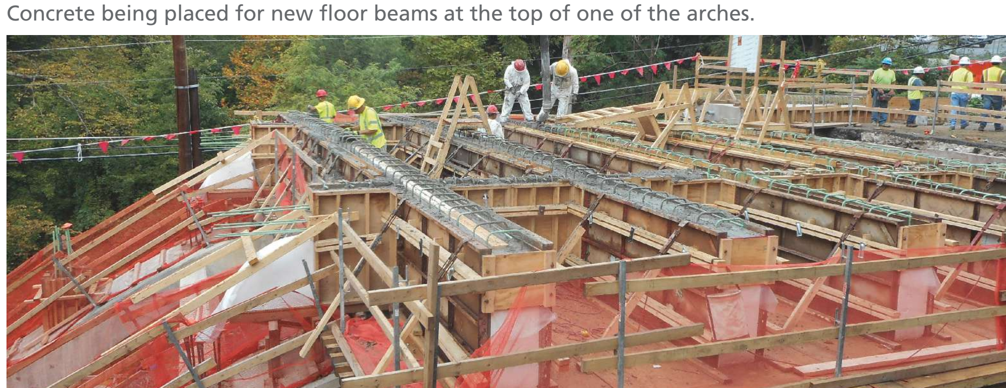
The reconstruction plans were painstaking in recreating and replicating the details of the existing bridge, which included extensive architectural features for the spandrel arches, floor beam overhangs, and columns. These architectural details were matched identically. However, details could not be exactly matched for the existing open-balustrade railings, which were significant to the Maryland Historical Trust. Fortunately, the Texas Department of Transportation Traffic Railing Type C411, which was crash tested and met the test requirements for the design speed and classification of Carroll Avenue, closely resembled the existing railings. This barrier received approval without comment.

Construction

The primary construction challenge for the project was access. Steep side slopes at each end of the bridge precluded the provision of construction entrances from Carroll Avenue. The solution was to provide an entrance off Sligo Creek Parkway; however, this location complicated matters because the parkway also served as the temporary detour route. Flaggers were employed daily to facilitate traffic flow while construction vehicles entered and exited the site.

One of the construction innovations that made the project such a success was the prime contractor's use of a work platform at the elevation of the arch supports. This work/demolition platform consisted of steel beams and timber flooring supported by shoring towers 15 to 20 ft above the floodplain of Sligo Creek. This platform solved

Concrete being placed for new floor beams at the top of one of the arches.



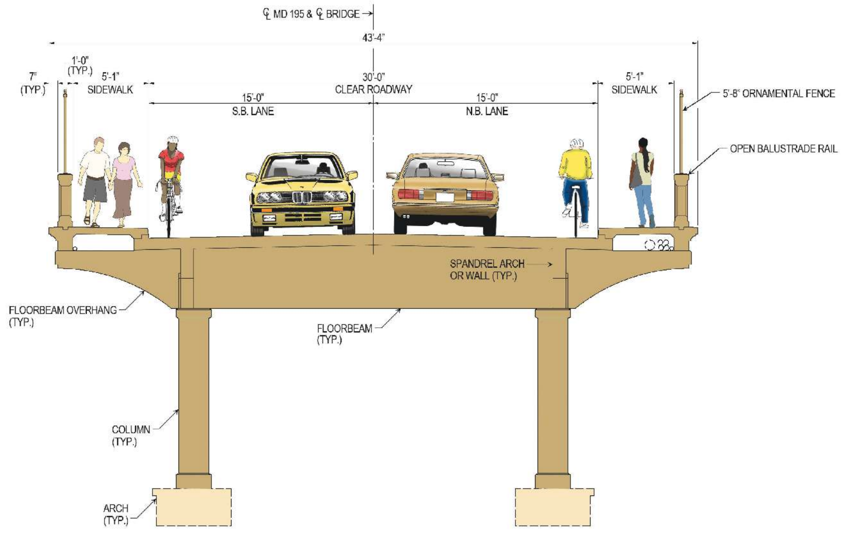
MARYLAND DEPARTMENT OF TRANSPORTATION STATE HIGHWAY ADMINISTRATION, OWNER

BRIDGE DESCRIPTION: Three-span, 220-ft-long, open-spandrel concrete arch

STRUCTURAL COMPONENTS: Repair of substructure units and arch ribs and replacement of columns, floor beams, and deck using 712 yd^3 of concrete MDOT SHA Mix No. 6 (28-day compressive strength of 4500 psi); 64 yd^3 of concrete MDOT SHA Mix No. 3 (28-day compressive strength of 3500 psi); 172,000 lb of epoxy-coated reinforcing steel; and 15,000 lb of black reinforcing steel

BRIDGE CONSTRUCTION COST: $9.3 million

AWARDS: American Council of Engineering Companies Maryland 2018 Outstanding Project Award; Portland Cement Association 16th Concrete Bridge Awards (2018) Award of Excellence



Rendering of proposed bridge section shows roadway with space for bicycles and sidewalks for pedestrians. Figure: Maryland Department of Transportation, State Highway Administration.

the problem of trying to work on the uneven terrain beneath the bridge and greatly facilitated construction demolition and build back. It also minimized the project's environmental impact. As concrete was demolished and dropped to the platform, small excavators transferred the material to the staging area, where the reinforcing steel was separated and loaded onto trucks for hauling.

The contractor made extensive use of polystyrene during demolition of the existing superstructure to protect the existing arches during construction and provide fillers in the formwork for creating the architectural details on the floor-beam overhangs, spandrel arches, and openings in the bridge railing. Most of the new concrete for the floor beams and deck slab was pumped from behind the abutments of the bridge. However, bringing in a concrete pump truck was not economical for placing the small volume of concrete needed for the short columns. Instead, the concrete placements were made in a fashion similar to the original construction in 1932, with workers lifting buckets and placing concrete by hand.

Design Criteria and Materials

All new elements of the bridge were designed in accordance with American Association of State Highway and Transportation Officials' *AASHTO LRFD Bridge Design Specifications,* sixth edition. The existing arches and substructure units were analyzed and load-rated in accordance with allowable stress design methods, which more accurately correlated to the original design.

All superstructure concrete consisted of MDOT SHA Mix No. 6 (which has a 28-day concrete compressive strength of 4500 psi). All reinforcing steel in the deck slab, floor beams, bridge barrier, and sidewalks on the bridge was epoxy coated. To extend the life of the new bridge deck slab, an epoxy-polymer concrete overlay was applied after the bridge deck slab was fully cured.

Pervious concrete was used on the sidewalk approaches to the bridge. This porous concrete feature allowed for stormwater infiltration and minimized runoff, providing additional stormwater management, which was considered a value-added improvement for the project because the project was exempt from stormwater management improvements per state requirements.

References

1. "Three Men Killed As Bridge Crashes at Takoma Park." *Montgomery News-Advocate,* January 13, 1932.
2. Hendrix, Steve. 2016. "Three Workers Once Died Rebuilding This Historic Md. Bridge. Now a New Makeover Is Under Way." *Washington Post,* May 13, 2016.

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View of completed Carroll Avenue Bridge from Sligo Creek trail.