PROJECT

RECONSTRUCTION

of the Ohio & Erie Canal Aqueduct Over Tinkers Creek

by Anthony Borrelli, Bergmann Associates

View of the re-watered Ohio & Erie Canal across Tinkers Creek. Manually operated sluice gates in the wall of the transition structure allow for regulation of canal water levels. Photo: Bergmann Associates.

Concrete allows for the successful reconstruction of a national treasure blending functionality with historic preservation

Constructed in the early 1800s, the Ohio & Erie Canal carried freight and passengers from the small towns and farms between the Ohio River and Lake Erie. This then opened up Ohio to larger ports and cities to the east and south.

Today, the surviving watered portion of the canal between Akron and Cleveland is managed by the National Park Service, including the aqueduct structure over Tinkers Creek. The canal and the associated structures are major attractions in the 33,000-acre Cuyahoga Valley National Park. The aqueduct is the only one remaining of the four originally constructed along this stretch of the canal. It is listed on the National Register of Historic Places and is a contributing resource to the larger Ohio & Erie Canal National Historic Landmark District.

A History of Repairs

With less than 5 ft of vertical grade separation between the canal and Tinkers Creek, the aqueduct is subject to frequent flooding of the creek, exposing the structure to stream forces, scour, debris impact, and ice jams.

As a result, on-going maintenance has been needed through the years. The aqueduct has been relocated, rehabilitated, and replaced several times, most notably in 1905 when a two-span iron truss supporting a timber plank trough was installed on the original masonry pier and abutments.

In 2007, after more than 100 years of weathering and frequent flooding, the National Park Service was forced to remove the steel and timber superstructure. Under emergency action, the canal was blocked off, a steel pipe conveyance system was installed to maintain water in the canal, and a new pedestrian bridge was constructed to restore towpath pedestrian traffic. Funding was then sought to design and construct a replacement aqueduct. Ultimately, the project was selected to receive funding through the American Resource and Recovery Act.

profile

OHIO & ERIE CANAL AQUEDUCT OVER TINKERS CREEK / CUYAHOGA VALLEY NATIONAL PARK, OHIO

BRIDGE DESIGN ENGINEER: Bergmann Associates, Rochester, N.Y.

PRIME CONTRACTOR: Abcon Inc., Youngstown, Ohio

GEOTECHNICAL CONSULTANT: D'Appolonia, Monroeville, Penn.

CAST-IN-PLACE CONCRETE SUPPLIERS: Carr Bros. Inc., Bedford, Ohio, and Newcomer Concrete Services, Norwalk, Ohio

The 1905 aqueduct structure consisted of a two-span truss supporting a timber trough. Note the low freeboard to Tinkers Creek and significant debris accumulation. Photo: National Park Service.

Concrete Well Suited to Project Challenges

An intensive study was conducted to evaluate concrete, steel, and timber aqueduct alternatives. Concrete was ultimately selected for its durability and low life-cycle costs.

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The added dead load and rigidity of the monolithic concrete construction was well suited to resist the stream forces, debris impact, and ice jams. The increased weight also helps to offset the significant buoyancy that can occur when the canal is drained and Tinkers Creek flood levels approach the top of the trough.

Debris snagging and sediment collection are also greatly minimized by the smooth formed surfaces of the concrete aqueduct bottom slab and sidewalls. Cast-in-place construction was well suited to the tight spatial constraints of the project, as well as capabilities of the small HUB-Zone (Historically Underutilized Business Zone) contractors bidding on the project. Lastly, the appearance of concrete provided a clear differentiation and textural contrast between the new aqueduct and the existing stone masonry, a key requirement of the Ohio State Historic Preservation Officer.

Concrete Details

The specified compressive strength of all the concrete was 4 ksi and featured an integral color admixture consistent with other newly constructed concrete structures in the park. For added durability, galvanized reinforcement was used throughout the structure.

Cast-in-place construction was well suited to the tight spatial constraints of the project.

Water tightness of the new aqueduct trough was a primary goal of the project. Polyvinylchloride (PVC) waterstops were used at all of the construction joints. Form ties, which pass through the formwork in most modern concrete construction, represented a potential seepage path and future maintenance concern and were not permitted. Rather, the contractor was required to externally brace all the formwork.

For added durability and protection of the concrete and reinforcement, a crystalline waterproofing admixture was used. This admixture fills small voids and microcracks with insoluble crystals

Center pier masonry reconstructed to just below the bottom of the aqueduct trough. Note the two concrete columns cast inside the pier that support the bearings for the new trough. Photo: Bergmann Associates.

NATIONAL PARK SERVICE, OWNER

BRIDGE DESCRIPTION: Two-span, concrete through girder and floor slab aqueduct supported on concrete integral abutments, and a masonry and concrete center pier

STRUCTURAL COMPONENTS: Two 96-ft-long, cast-in-place concrete through girders (7 ft 2 in. by 1 ft 8 in.), 1-ft 6-in.-thick concrete floor slab spanning 21 ft 11 in., twenty-four 7-in.-diameter micropiles with a maximum depth of 65 ft

BRIDGE CONSTRUCTION COST: $1,857,000 ($770/ft^2)

Placement of the galvanized reinforcement for the new trough floor slab and through girder sidewalls. Photo: Bergmann Associates.

increasing the water tightness of the structure.

The New Structure

The new aqueduct consists of a 96-ft-long, two-span through girder and floor slab system continuous over the center pier. The original aqueduct cross section was considered to be a historic feature that had to be maintained. Through girders, 1 ft 8 in. thick and 7 ft 2 in. deep, make up the sidewalls of the trough, and a 1-ft 6-in.-thick concrete slab spans 21 ft 11 in. between the girders making up the aqueduct floor.

At each end, the trough is supported on an integral concrete abutment featuring a single row of five micropiles. The abutments were set back approximately 10 ft behind the existing stone abutments to avoid interferences during the micropile installation.

In order to smoothly transition from the wider, sloped earth canal section to the narrower vertical walled aqueduct section, concrete U-frame slab-on-grade "transition" structures were located at each end of the aqueduct. The joint between the transition structures and aqueduct trough features two sets of 1.5-in.-diameter, PVC, center-bulb waterstops to prevent leakage at the joint and allow for the necessary thermal movements. Stainless-steel cover plates protect the waterstops and keep out sediment and debris.

To minimize the potential for canal water to seep under the aqueduct, concrete cut-off walls were provided at the ends of the transition structure and a 1-ft 6-in.-thick clay liner was added to the canal bottom.

The original aqueduct featured two, 4 by 4 ft "waste gates" in the downstream sidewall of the timber trough. These gates provided National Park Service staff with the ability to regulate the water levels in the canal, either after a flood event or for maintenance purposes. Replicating such large gate openings in the through girders would have compromised the structure's capacity.

Rather, two 2-ft-square, manually operated sluice gates were provided in the side wall of the southern transition structure and discharge into 3-ft-diameter, outfall pipes, buried behind the existing stone abutments, out-letting downstream to Tinkers Creek.

Pier Reconstruction

The existing 44-ft-long masonry pier was significantly deteriorated including cracked and dislodged stones, missing mortar joints, heavy vegetation growth, and settlement at the upstream end. The 112 ashlar sandstone blocks making up the pier were completely dismantled and the pier fully reconstructed as part of the project.

The bottom two courses of stones below the creek bed were removed and replaced with a new concrete footing supported on two rows of seven micropiles. This new footing not only provided long-term scour protection and a stable surface on which to reconstruct the stone masonry, but it also allowed the displaced stones to be used for stone repairs in the upper reaches of the pier.

Twin 4 by 3 ft concrete columns extending up from the pier footing were cast inside the core of the stone pier to support the stainless steel and elastomeric bearings that carry the aqueduct trough. This provided an entirely new load carrying system and avoided loading the sandstone masonry.

Various labor-intensive hand repair techniques were used to restore the historic stonework including re-tooling the exposed stone faces that featured a bush-hammered surface with smooth window pane margins, "dutchman" repairs consisting of piecing in new corners of chipped stones, and full replacement of the individual stones in some cases.

Mortar consisting of sand, hydraulic hydrated lime, and cement—and tinted to match the original mortar—was used in all of the bedding joints and re-pointing efforts.

AESTHETICS COMMENTARY
by Bradley C. Touchstone

Sometimes the most valued historical assets are created to solve a specific challenge in a clever and innovative way. Such is the case with the Ohio & Erie Canal Aqueduct over Tinkers Creek. It would be unreasonable and dishonest to rebuild the aqueduct as originally constructed. When restoration is not possible, the Advisory Council on Historic Preservation encourages us to create replacements that utilize current methods and materials to capture the essence of the original structure while avoiding mimicry.

The new aqueduct design pays homage to the original structure through the use of form, scale, and texture. At the same time, the replacement is built using the latest construction techniques and materials in a manner that is clearly of its time. The use of concrete for the superstructure in lieu of the original materials makes perfect sense. Concrete has a unique ability to accommodate requirements for span length, durability, and water tightness. Use of form liners to develop a rusticated pattern on the superstructure face further illustrates the flexibility of this material. The patterns used soften the appearance of the bridge and will allow the bridge to age in an elegant fashion.

The resulting restoration project adheres to the guidance of the Advisory Council on Historic Preservation and subtlety and cleverly updates the original structure while maintaining the mystique of this entertaining and informative aqueduct for all who visit.

A Stable Foundation

The pier and abutments feature a deep foundation system consisting of 7-in.-diameter micropiles extending into the clay and silty sands beneath the aqueduct supporting more than 1000 tons of water, concrete, and stone load. The 65-ft-long micropiles featured a concrete filled upper steel casing, with a lower 50-ft-long grouted bond zone. In addition to their high axial and lateral capacity, micropiles were ideally suited for this project site given the small footprint of the installation equipment, the ability to drill through potential obstructions, and the need to minimize vibrations on the surrounding masonry abutments.

Bringing Back the Water

On September 22, 2011, after a year of construction, the original canal system was restored and the waters of the Ohio & Erie Canal flowed once again over Tinkers Creek as they have done for the past 166 years. Unlike its predecessors, the new, all concrete aqueduct structure will provide Cuyahoga Valley National Park and its visitors with a functional piece of history well into the twenty-first century.

Anthony Borrelli is the New York bridge division manager for Bergmann Associates in Rochester, N.Y., and the project's engineer of record.

For additional photographs or information on this or other projects, visit www.aspirebridge.org and open Current Issue.

Elevation view of the new aqueduct and fully reconstructed masonry pier. Photo: Henry G. Russell Inc.