Replacement of the Troup Howell Bridge, Rochester, New York

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The Troup Howell Bridge carries I-490 over the Genesee River and several streets in downtown Rochester, New York. When deterioration necessitated a new bridge, engineers sought a context-sensitive replacement. The bridge’s location affords opportunities for aesthetic enrichment: it is set in the foreground of the city skyline, which includes architecturally noteworthy buildings that house mainstays to international businesses such as Eastman Kodak, Xerox, and Bausch & Lomb. The project design team included the New York State Department of Transportation, Erdman Anthony and Associates, Inc., and H2L2 Architects. An aesthetics committee consisting of local government officials, adjoining neighborhood representatives, American Institute of Architects members, and artists provided feedback throughout the design process, which ensured that the solution fit the environment. Many of the committee preferences were implemented in the final design. The centerpiece of the new eight-span bridge will be a 132-m (433-ft) long through arch span crossing the river. The arch will have three steel box ribs, Vierendeel-style braces, and a fanned hanger arrangement supporting the deck system. Aesthetic enhancements were achieved in many areas of the main span design. Arch anchorages were set back from the riverbanks to allow shoreline promenades beneath the bridge. Accent lighting and sculpted floor beam shapes were provided to enhance visual interest from the promenades. Because of the through arch design and the high volume of daily traffic over the bridge, significant challenges were addressed during construction. Structural design details were developed to allow for staged construction, which permitted the bridge to remain open throughout construction.

As in many older northeastern cities, downtown interstate construction in Rochester, New York, during the 1970s dislocated neighborhoods, enabled suburban migration, and altered the character of the downtown. To acknowledge and attempt to mitigate this past disruption, federal highway legislation (i.e., Section 109 of Title 23, United States Code) incorporated the philosophy of providing context-sensitive solutions, particularly when faced with reconstruction in urban environments. New York State embraces this philosophy, and the New York State Department of Transportation (DOT) sought to provide a context-sensitive design for Rochester’s Troup Howell Bridge Replacement. Because the cornerstone of a successful context-sensitive design process is public involvement, early and continuous engagement of the community was crucial. Beyond the project engineering design team, New York State DOT created an aesthetics committee made up of diverse individuals from the Rochester area to ensure community acceptance and support of the bridge design aesthetics. This committee met periodically with the design team, gave feedback to proposed designs, and worked together to identify and solve aesthetic issues as they arose.

The New York State DOT process resulted in an overall improved project, a truly unique structural solution, and a sense of community involvement and excitement that continue to grow as the bridge is being built. This paper discusses the unique elements of the bridge’s main span design and how the aesthetics committee contributed to the process, as well as how the resulting construction challenges were resolved.

PROJECT BACKGROUND

Rochester has a metropolitan population of approximately 1.2 million and is situated on the southern shore of Lake Ontario. The Genesee River bisects the city and flows northward to the lake. An expressway dubbed the Inner Loop surrounds the city’s central business district, which is home to international businesses such as Eastman Kodak, Xerox, and Bausch & Lomb. A portion of this loop spans the river in two locations. The Troup Howell Bridge carries the southern leg of the Inner Loop along with I-490 (Figure 1). I-490 provides connection from eastern and western suburbs to center city.

This bridge was originally constructed in 1954 as an urban boulevard. It connected Troup Street on the west side of the river to Howell Street on the east. The bridge consisted of 15 steel multigirder spans and carried six lanes of traffic and two sidewalks (Figure 2). In 1974, the approach and bridge were reconfigured to become part of the federal Interstate system as a fully access-controlled facility. This was accomplished by redecking and widening the original structure and by reconstructing the east end to provide exit ramps to downtown (Figure 2). The resulting bridge contained 12 spans and carried eight expressway lanes. The bridge spans city parking lots and Exchange Street on the west side and the river, a bicycle trail, the I-490 eastbound on-ramp, and South Avenue on the east side. Both Exchange Street and South Avenue are major arterials that feed the center city.

In 1996, New York State DOT commissioned Erdman Anthony and Associates to perform an in-depth bridge inspection and structural evaluation. The results indicated that after 42 years of pounding truck traffic, the bridge had 12 porous deck joints, a delaminated structural slab, pack rust between plies of built-up girder flanges, and fatigue cracking at partial length cover plate terminations. There were also five lines of pin and hanger girder connections, many with pin section loss, and more than 100 tall steel bearings that were vulnerable to toppling during a seismic event. Given the deteriorated conditions, the vulnerable components present, and the ever-increasing bridge maintenance funds necessary, New York State DOT decided it was time to replace the bridge.
New York State DOT recognized early that aesthetics would play an important role because of the prominent location of the project. To address this challenge, a design team was created that included bridge and highway engineers from Erdman Anthony, infrastructure architects H2L2, and an aesthetics committee. Although it was atypical of New York State DOT projects, architects were included to develop aesthetic alternatives. The aesthetics committee included representatives from local city, county, and state government; the Arts and Cultural Council; the Landmark Society of Western New York; the Greater Rochester Visitors Association; and the American Institute of Architects—anyone who could help ensure that the solution fit the context. The committee met approximately four times a year from 1998 to 2003.

In 1999, a bridge replacement type study was performed. Six different bridge types were evaluated: short-span steel multigirder, long-span steel multigirder, prestressed concrete box girder, steel box girder, steel through arch, and cable stayed. After considering the bridge type options at a public hearing, the community overwhelmingly chose the steel arch. There was consensus on a fundamental point: the site deserved a “gateway” or “signature” span that would frame the river as well as the city skyline. Given that several multispan masonry arch bridges are located downstream, the committee decided a more modern arch—“but not too modern”—would be the appropriate bridge type. Not only was there aesthetic benefit, the through arch structure allowed the I-490 profile to be lowered approximately 1 m (3.2 ft), which partially mitigated a nonstandard I-490 stopping sight distance.

In 2000, during concept development, three day-long charrettes were held to further brainstorm ideas on bridge configuration and...
span layout. As detailed design plans were developed between 2001 and 2003, the committee shifted its focus to discuss bridge details such as member shape and lighting. Throughout the process, New York State DOT and H2L2 facilitated these discussions, ensuring clarity of issues and proposed solutions. When an idea or proposed solution was identified by the engineers as not structurally feasible or too costly, it was discarded. The committee respected these guidelines and always achieved consensus on the ideas that were pursued. The process ensured that the expertise and experience of the designers were not overruled but rather brought to the community table for understanding and enhancement. The plans, specifications, and estimate were completed in June 2003.

The bridge construction project was awarded to Edward Kramer and Sons, Inc., in November 2003. A ground-breaking ceremony was held May 6, 2004. The project is slated to be complete in the summer of 2007.

**UNIQUE STRUCTURAL FEATURES**

The new eight-span structure will be 364 m (1,194 ft) long. The centerpiece will be a 132-m (433-ft) long through arch span crossing the Genesee River (Figure 3).

Most arches built in the last several decades have been of the tied arch style. One benefit of a tied arch is that it does not require a large foundation. In many cases, however, the tie becomes deeper than the arch rib to resist arch thrust. When given the choice between a tied arch and a true arch design, the committee chose the true arch. Feedback indicated that the thinner deck was more desirable. In this case, the Troup Howell Aesthetics Committee grasped intuitively what Fritz Leonhardt asserted in his book on bridge aesthetics: “... the best appearance is obtained, if the arches are designed to carry all loads and bending moments, and if the deck is longitudinally as shallow as possible in order to emphasize the character of the deck suspension” (1). A true arch requires transmission of thrust to a solid competent foundation, preferably bedrock. Because extremely competent bedrock (i.e., allowable bearing pressure is 1.2 MPa or 12.5 tons/ft²) is located within 4.0 m (13.1 ft) of the ground surface (Figure 4), the choice of a true, two-hinged arch became structurally and economically feasible.

The river is confined at the site by concrete walls along each bank. River walks on both upstream banks had been constructed recently, and the city wanted to extend the walkways under the bridge. To allow for construction of the foundations in the dry and for the river walks, the span was set at 132.0 m (433.0 ft).

In the bridge section, it was necessary to increase median shoulder widths to meet standards, so it also became necessary to further separate the I-490 eastbound and westbound alignments (Figure 5). The amount of separation, however, had to be kept to a minimum owing to the presence of structures located on the edges of both approaches. The historic Corn Hill neighborhood and the Public Safety building are present on the west side, and bridge piers for an overhead ramp bridge are on the east side (Figure 6). These constrictions precluded the use of four-arch ribs, two supporting each travelway,
which is the common arrangement for bridges of this type. In the end, the design team decided to support both eastbound and westbound travelways by only three ribs. Precedent for three-rib construction was found in Berlin, Germany, with the Arch Bridge over the Britz Canal, opened to traffic in 2001. Ribs for the Troup Howell Bridge are steel boxes. The center rib is 3.000 m × 1.170 m (9.8 ft × 3.8 ft) and the exterior rib is 1.780 m × 1.170 m (5.8 ft × 3.8 ft) (Figure 7). They will be spaced at 19.9 m (65.3 ft). The boxes are made with a wider top flange than bottom, and aesthetic stiffener plates are added at each hanger location. This overhang geometry provides the illusion of a trapezoid and promotes the creation of shadows, which enhances visual interest.

The arch rib bracing is Vierendeel type to maximize the view to open sky. Six brace lines connect the ribs. The braces are also steel boxes and are dog-bone–shape in plan view (Figure 8). The braces also are used to support expressway lighting. Fixtures are mounted within bottom flange penetrations at each brace. This arrangement eliminates the need for conventional lighting poles mounted on the bridge deck, which the committee believed would visually conflict with the hanger layout.

![Figure 5](image)

**FIGURE 5** Bridge sections: (a) before and (b) after.

![Figure 6](image)

**FIGURE 6** Aerial plan (limited alignment shift).
Provisions to assist future bridge inspectors also were added to the ribs and braces. Six access doors were added to each rib, and two doors were added to the top of each brace. Handrails were added to the longitudinal stiffeners in each member, and steps were placed in the steeper portions of the bottom flange on the inside of the box. All boxes are made with ASTM A709M Grade 345W (A588) steel and were not designed to be airtight. Experience on other bridges has shown that interior condensation can create conditions that accelerate corrosion, so the Troup Howell design incorporates ventilation and drains. In addition, the interior of each box is painted white to facilitate future biennial inspections.

Rather than vertical hangers, the committee preferred a fan shape orientation as seen from the elevation (Figure 3). A small tie (i.e., C380 × 50 or C15 × 33.9 channels oriented back to back) was added at deck level to resist the horizontal hanger component resulting from this arrangement. The tie extends from the first to the last hanger and does not connect to the rib. As a result, the arch thrust will still be carried by the foundation. Subsequent to structural analysis, it was determined that the fan orientation not only provided visual interest but also was beneficial in transmitting longitudinal earthquake load from deck level, back to rib, and then down to foundation. Two structural strand hangers are provided at each of the 19 panel points for redundancy. Strand diameter varies from 38 mm (1.5 in) to 79 mm (3.125 in) across the span.

In designing the hanger connections, care was taken to ensure maintenance forces would not be able to easily adjust hanger tensions. Experience on other bridges has found that when adjustments can be made at deck level, the easy access to the connection can be problematic. Maintenance workers may unknowingly attempt to increase hanger loads by tightening, thereby creating unintended loads and redistributions. Adjustments can be made only at the rib end in the Troup Howell design. At the deck level, a pivot plate detail was incorporated to help keep the load in each of the two hangers at any panel point approximately the same (Figure 9). The
relatively large pivot plates met the committee’s request for enhanced visual interest beneath the bridge.

Because a design goal was to carry the river walks beneath the bridge, the underside of the bridge would be exposed to the public. The committee asked if the floor beams could be modified to provide visual interest for pedestrians. The design team’s solution was the use of rounded floor beam ends and a sculpted floor beam with variable depth (Figure 10). The floor beam depth was made shallowest at hanger points and deeper between. The final shape not only met the committee’s desire for visual interest but also proved structurally efficient for handling shear and bending stresses. All 19 floor beams were detailed with a similar shape. The rounded floor beam end also will serve to house aesthetic lighting that, at night, will shine upward along the hangers and illuminate the underside of the arches and braces.

Another committee request was a bridge railing system that would allow views of the surrounding area by passengers in vehicles on I-490. The railing detailed for this part of the bridge contains two steel tubular rails at the top of the concrete barriers that permit viewing. The railings are based on a design for a Pennsylvania Department of Transportation (DOT) arch bridge in Pittsburgh. The Pennsylvania DOT design was found to be interstate compliant and was given recent FHWA approval. This system will be used for the first time in New York State on the Troup Howell Bridge.

The bridge steel will be painted with the standard New York State three-coat system: inorganic zinc primer, epoxy intermediate coat, and polyurethane final coat. The final coat on the arch ribs, braces, and hanger plates will be silver, and the framing below the deck will be reddish brown. The community had a direct impact on paint color selection. During the neighboring Corn Hill summer festival, which usually draws approximately 100,000 attendees, the design team set up an exhibitor’s booth and invited the community to vote on a bridge paint color (Figure 11).

CONSTRUCTION CHALLENGES

A major project challenge was detailing the plans for staged construction. The I-490 corridor carries approximately 50,000 annual average daily traffic in each direction. Traffic modeling indicated that bridge closure was not an option without gridlock on city streets, so staged construction was pursued.

New York State DOT’s concern about maintaining traffic was great enough to include time-related construction contract provisions in the form of “A + B” bidding. This is a method of awarding a project on the basis of both cost and time. Each bid submitted consisted of two parts: the A portion is the sum bid for contract work items; the B portion is the time in calendar days, proposed by the bidder to complete the project, multiplied by a daily road user cost determined by New York State DOT. The contract is awarded on the basis of the sum of the A and B portions of the bid. The contract after award is limited to the A portion of the bid. A disincentive provision is enforced should the contractor fail to complete the work in the length of time bid. An incentive provision is included to pay for acceleration costs and to reward the contractor for earlier completion. For the Troup Howell project, penalties will be imposed when the time allotted for a reduction in normal traffic flow (i.e., down to two lanes of traffic each way) exceeds the contractor’s bid of 657 days.

The plans called for construction in three stages. Stage I would allow construction of the majority of the new foundations beneath the existing bridge. By locating new substructure elements where none currently exists, more construction could be accomplished without major disruption to I-490 traffic.

Stage II requires the demolition and replacement of the eastbound bridge. In this stage, all I-490 traffic is shifted to the westbound side, and the number of lanes is reduced from three lanes to two in each direction. At the conclusion of Stage II, all I-490 traffic will be shifted to the new eastbound bridge (i.e., two lanes in each direction). During Stage III, the westbound side will be demolished and rebuilt (Figure 12).

For the rib and brace erection, the contractor is proposing to build all 3 ribs and 12 braces in one season during Stage II. The proposal, currently under New York State DOT review, includes provisions for nighttime closures of the westbound side of the bridge. With the westbound temporarily closed each night, the northernmost rib and connecting braces may be erected. The proposal begins the nighttime closure at 9:00 p.m. and reopens the westbound lane at 6:00 a.m. each morning. The contractor is currently anticipating 9 nights of temporary closure.

FIGURE 10 Floor beam view from pedestrian walk.

FIGURE 11 Design team booth at Corn Hill festival.
Detailing the floor beams for staged construction also presented design challenges. Our design goal was to make the floor beams continuous over the center hanger support in the permanent condition for redundancy. In Stage II, after the new eastbound is constructed, the floor beams will be pinned to lugs welded to the center hanger plate (Figure 13). A similar connection will be provided on the westbound side during Stage III. At the completion, flange splice plates are bolted to the adjacent floor beam flanges to achieve continuity.

CONCLUSION

Every well-designed bridge is technically “context sensitive,” but the best are also aesthetically pleasing. By engaging a citizen’s committee in the design process, the “context” was broadened to include the specific concerns and interests of residents and bridge users. This interaction among the designers and the public facilitated increased understanding of the bridge project and its value to the community.

This project is an excellent example of how aesthetic considerations, structural need, and economic limitations can be integrated to provide a visually exciting bridge. Each aesthetic element was analyzed to ensure that it provided a visual “value.” Many of the implemented committee suggestions not only provided pedestrian and
aesthetic value but also delivered structural benefits. The committee’s contributions also will provide more pedestrian-friendly access to the riverfront within a more pleasant setting (Figure 14).

ACKNOWLEDGMENTS

The owner of this project is the New York State DOT. The bridge was designed by Erdman Anthony and Associates in association with all members of the aesthetic committee. Edward Kraemer and Sons is the general contractor.

REFERENCE


The 6th International Bridge Engineering Conference Committee sponsored publication of this paper.