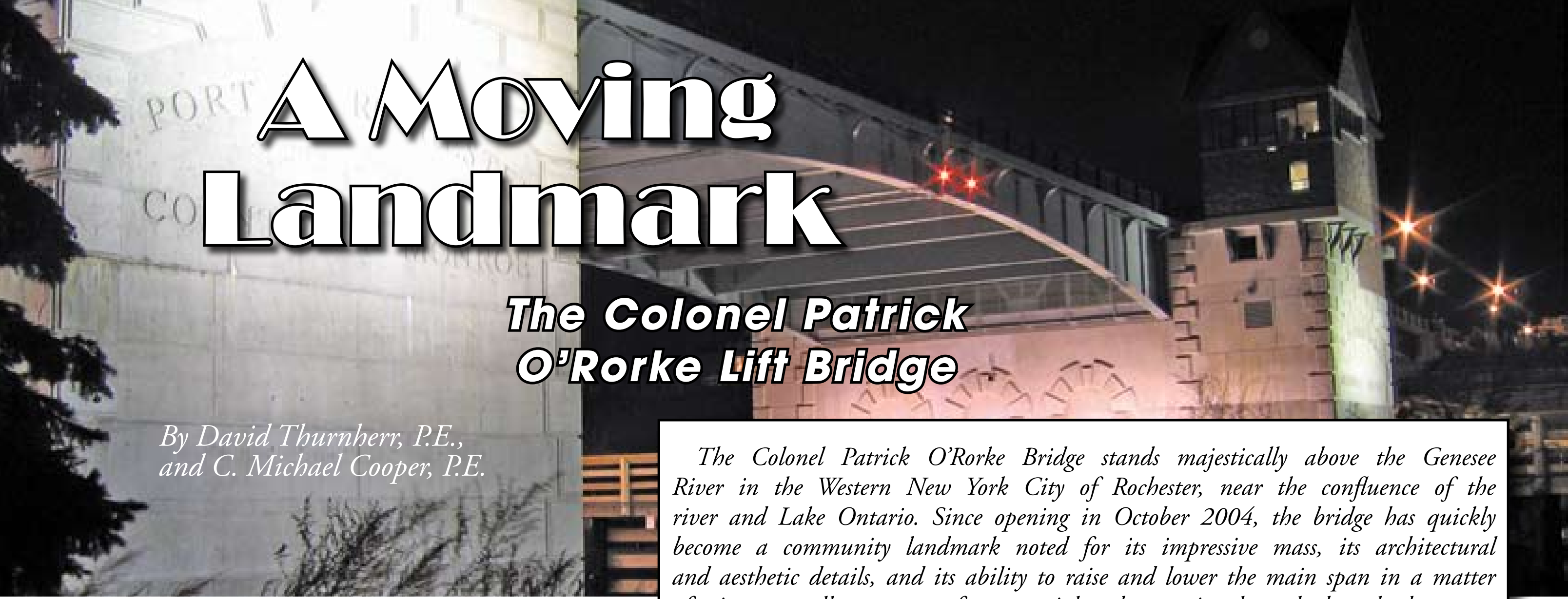


A Moving Landmark

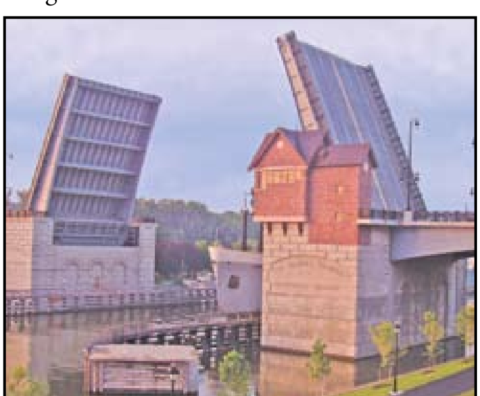
The Colonel Patrick O'Rorke Lift Bridge

By David Thurnherr, P.E., and C. Michael Cooper, P.E.

O'Rorke Bridge at night

The Colonel Patrick O'Rorke Bridge stands majestically above the Genesee River in the Western New York City of Rochester, near the confluence of the river and Lake Ontario. Since opening in October 2004, the bridge has quickly become a community landmark noted for its impressive mass, its architectural and aesthetic details, and its ability to raise and lower the main span in a matter of minutes to allow passage of commercial and recreational vessels that ply the waters of the Port of Rochester, the Genesee River, and Lake Ontario.

The O'Rorke Bridge is the centerpiece of a project that replaced a functionally obsolete and structurally deficient lift bridge on a new alignment some 250 feet upstream of the existing bridge. The new bridge consists of a 243-foot long bascule span over the Genesee River flanked to the west by a 148-foot long single-span steel approach structure, and to the east by a 530-foot long, curved and splayed three-span continuous steel approach structure, and carries twenty-two thousand vehicles daily. The O'Rorke Bridge is massive by comparison to its predecessor, standing 22 feet higher and twice as wide, and boasts a solid concrete filled steel grid deck rather than the open deck that is more typical of this type of moveable bridge. Impressive as its physical stature may be, the inner workings of the bridge are equally remarkable, including the precisely tuned electrical and mechanical systems responsible for lifting and lowering the bridge on-demand, the numerous foundation systems supporting all that mass, and the bridge's capacity to withstand extreme design events.



O'Rorke Bridge Aesthetic Treatments

The Workings of a Scherzer Rolling-Lift Bascule Bridge

A conventional fixed bridge structure was eliminated from consideration in the planning process because the vertical clearance mandated by navigational regulations would have required longer approach structures, which were determined to have unacceptable impacts to the adjacent communities. Of the available moveable bridge systems, designers selected a double-leaf, Scherzer rolling-lift Bascule Bridge. The superstructure of this moveable bridge type simultaneously lifts up and rolls away from the channel as the bridge opens, providing the required unobstructed clear channel opening with approximately 10% less span length.

When in the closed position, a center lock mechanism transfers live loads between the two leaves of the bascule span. Because the rolling lift bridge translates horizontally away from the channel as it lifts up, the center lock mechanism is a simple tongue and groove system that requires no moving parts and is virtually maintenance free. The tail ends of the bascule girders underlap a short cantilever segment of the approach span fascia girders.

The key principle in the operation of a Scherzer rolling-lift bascule bridge is balance. The dead load weight of the bascule leaves is balanced by large concrete counterweights hidden inside the bascule piers. In the case of the O'Rorke Lift Bridge, the 780,000-pound weight of each lift span leaf is balanced by 2,710,000-pound counterweights. The exercise of balancing the span is detailed and exact, and results in very little external force required to open and close the bridge. In fact, the bridge's machinery features an input that allows emergency operation to be performed via a large hand drill. Both the vertical and horizontal location of the center of gravity of the bascule span must accurately be determined so that the span will remain balanced throughout its full range of movement. In addition to detailed analysis during design and fabrication, strain-gage instrumentation installed on the drive shaft measured the stresses during lifting, allowing the contractor to further fine tune the span balancing process in the field.

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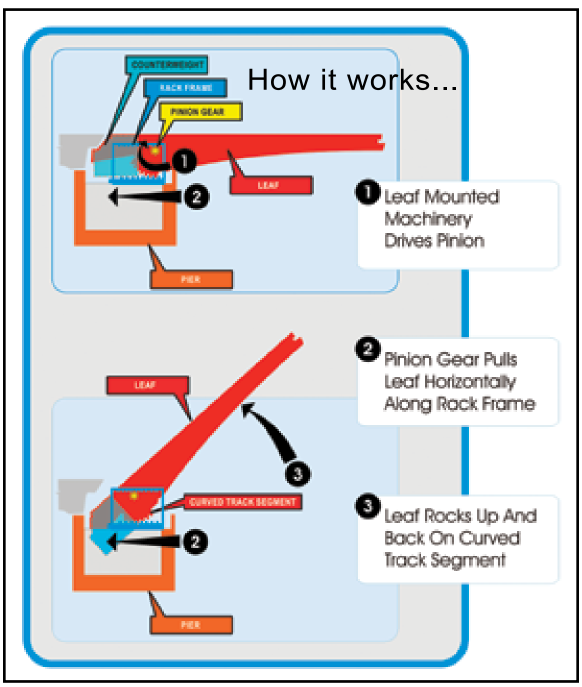

Illustrating the Movements & Geometry Associated With Opening a Scherzer Rolling Lift Bridge

The machinery room is located between the bascule girders, and rotates along with the leaf. The span drive machinery for each leaf consists of interconnected dual electric motors coupled to primary and secondary gear reducers. Machinery brakes hold the bascule leaf against wind and other unbalanced loads, while motor breaks control the leaf during emergency stops or loss of power. Standby power is supplied by an auto-start diesel generator located inside the operator's house.

A computerized control system allows semi-automatic operation of the drive system, and a manual system provides backup control. Quality control and quality assurance activities during construction included substantial inspection, testing, and systems integration conducted prior to shipping equipment to the site. As part of the contract requirements, the Contractor trained the existing bridge staff on the operation and maintenance of the bridge, and provided operation and maintenance manuals as well as a video for use in training future bridge operators.

Given these intricate workings of a moveable bridge, construction tolerances are far more exacting than for a conventional fixed bridge. A rolling-lift bridge operates and travels on mating surfaces consisting of curved and flat castings machine-finished to 0.01 inches to assure a smooth riding surface during operation. The castings were also set to within a 0.03-inch positional tolerance prior to casting concrete around them. In addition, the fabricator erected the entire bascule bridge framing system in the shop to ensure proper alignment among the numerous components, and to identify problems before shipping any steel to the site for erection. Finally, a physical and virtual roll-through of the bascule girders verified fabrication and erection tolerances prior to total erection of the bascule span.

O'Rorke Bridge as a Sailboat Passes

O'Rorke Bridge as Design Vessel is Passing Through

Behind the Scenes, Extreme Design

Supporting the massive bascule span leaves and counterweights are equally robust pier structures that transfer over 27 million pounds to the foundations below while providing interior space for the movement and operation of the bridge. The west pier is approximately 100 feet wide by 40 feet long, and stands 100 feet tall at the top of the control house. The east pier does not carry a control house and is somewhat smaller than the west pier. A sloping rock surface, large dead loads, high seismic loading and depth of the water presented unique design challenges that required innovative and creative solutions.

The river at each bascule pier is consistently about 25 feet deep; however, the underlying soil and rock strata at either side of the bridge are quite different, resulting in two markedly different foundation systems. The east pier is supported on 114 steel bearing piles extending over 100 feet to bedrock. The rock elevation at the west pier was considerably shallower, however, where the foundation consists of 24, 54-inch diameter, drilled shafts socketed into rock and varying in length from 30 to 60 feet.

In addition to the mass of the super- and substructures, a lack of formal guidance from AASHTO for the seismic design of bascule bridges further challenged the design process. The design team, in conjunction with the New York State Department of Transportation (NYSDOT), developed project specific seismic design criteria that included designing for no collapse but allowing reparable damage, designing for a reduced seismic load when the bridge was in the open position to account for the unlikelihood of both conditions occurring concurrently, and employing site specific spectral accelerations. With these guidelines in hand, designers created a site specific global model of the structure, input a variety of data representing variable foundation stiffnesses, time histories for rock and soil motion, as well as potential soil liquefaction conditions, and extracted resulting seismic design forces for an assortment of conditions and load cases.

Under normal loading conditions, the approach spans serve as live load restrainers necessitating the approach girder bearings to be fixed at the bascule piers. However, during a seismic event, fixed bearings would impart significant force from the approach spans to the bascule piers resulting in extensive damage that would be difficult to repair. To minimize the seismic forces transmitted to the bascule pier, designers specified innovative fused lead-core rubber isolation bearings featuring an elastic restraint system (ERS). Under service loads, the ERS restricts movement in the bearings, preventing longitudinal translation of the structure. During a seismic event, the fused bolts in the bearings will fail at a prescribed force allowing the isolation component of the bearings to absorb the seismic energy and protect the bascule piers from damage.

Another extreme load case, collision of a vessel with the bascule piers, could have significant cost implications with respect to disruption of service and damage to the bridge, as well as hindering navigation in the Genesee River. A site specific statistical analysis in accordance with AASHTO guide specifications determined the design vessel to be a 500-foot long, 15,000 displacement ton bulk freighter traveling downstream at 3.5 knots. An innovative pier protection system consisting of pipe-pile and shaft-supported concrete dolphins was located at each quadrant of the approach channel, with an intermediate fender system faced with tropical timber to provide continuity of pier protection between the dolphins. Engineers designed the pier protection system using an iterative analysis process based on limit state structural design, energy absorption, and non-linear soil-structure interaction.

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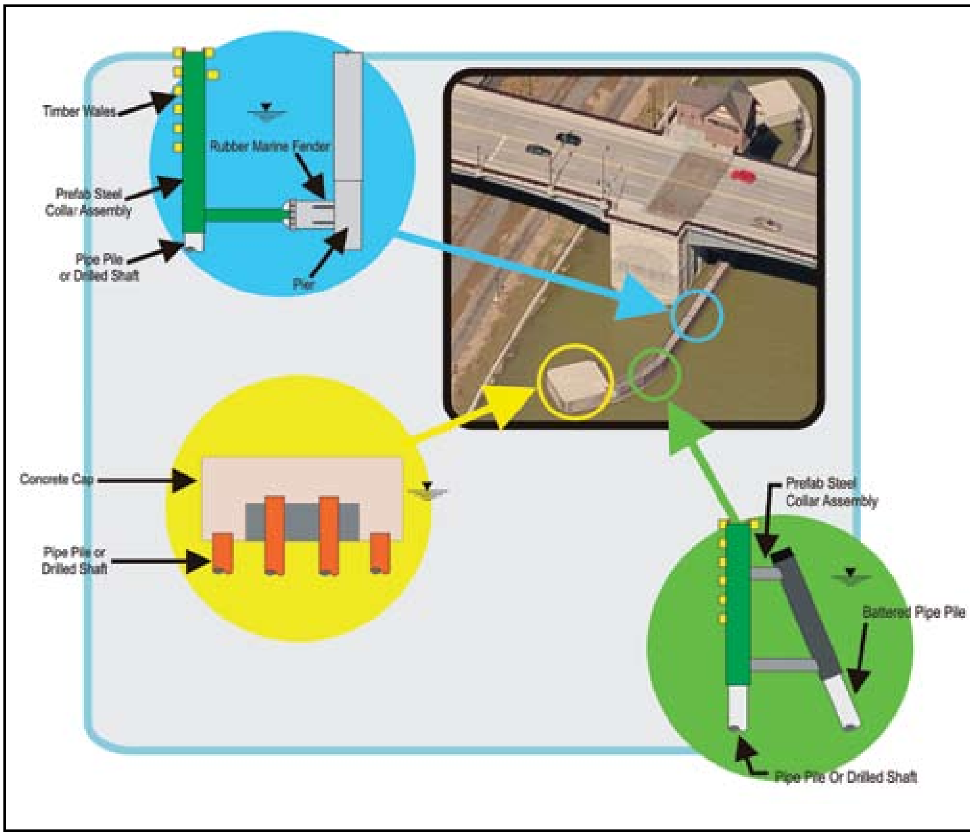

Rendering of Fender System Components

Project Team

The design and construction of a large and complex project such as the O'Rorke Bridge is a considerable undertaking. The authors would like to recognize the considerable efforts of all the project participants:

- **OWNER'S GROUP**:
  - o Monroe County Department of Transportation
  - o NYS Department of Transportation
- **DESIGN TEAM**:
  - o Bergmann Associates, P.C. (Prime Consultant)
    - Mechanical, Electrical & Control Design
    - Superstructure Design
    - Pier & Foundation Design
  - o Hazelet & Erdal/URS Corp. - Superstructure Design
  - o NYS Department of Transportation - Geotechnical Design
  - o Imbsen & Associates Inc. - Seismic Design
  - o Fisher Associates - Survey
  - o Barbara Thayer, P.C. - Architecture
- **CONSTRUCTION TEAM**:
  - o Crane Hogan Structural Systems - General Contractor

Aesthetics & Beauty Add Finishing Touches

Early in the design process, public meetings allowed community participants to offer their input on the potential aesthetic impacts of the project on the surrounding area. Of foremost importance to the community was ensuring that the project complement and preserve the historic character of the neighborhoods in which it was located. During final design, a Visualization Task Force (VTF) comprised of representatives from the owner's group, surrounding communities, and the design team, took up the challenge of developing aesthetic and architectural guidelines to which the project should aspire. With the recommendations of the VTF as their guide, designers incorporated nearly $2.6 million worth of aesthetic enhancements into the $80 million project, resulting in a design that held true to the character of the community and helped solidify the bridge's status as an area landmark. Concrete surface treatments and form liners, historically appropriate materials such as copper roofing and stone building façade, substructure shapes reflecting the arches of a nearby parkway, complementary lighting, and other similar details highlighted architectural elements drawn from the surrounding community.

Opening & Dedication

After nearly ten years of planning and engineering, and four years of construction, on October 2, 2004, the project was officially opened to traffic. Dedicated in homage to Colonel Patrick O'Rorke, a local Civil War hero, the bridge is heralded by many as a gateway and landmark that re-shaped and rejuvenated the Port of Rochester. Many consider this project to be a cornerstone upon which future waterfront and urban revitalization will flourish.▪

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*Bergmann Associates is an engineering and architectural firm with offices in New York, New Jersey, Florida, Pennsylvania and Michigan. (**www.bergmannpc.com**)*