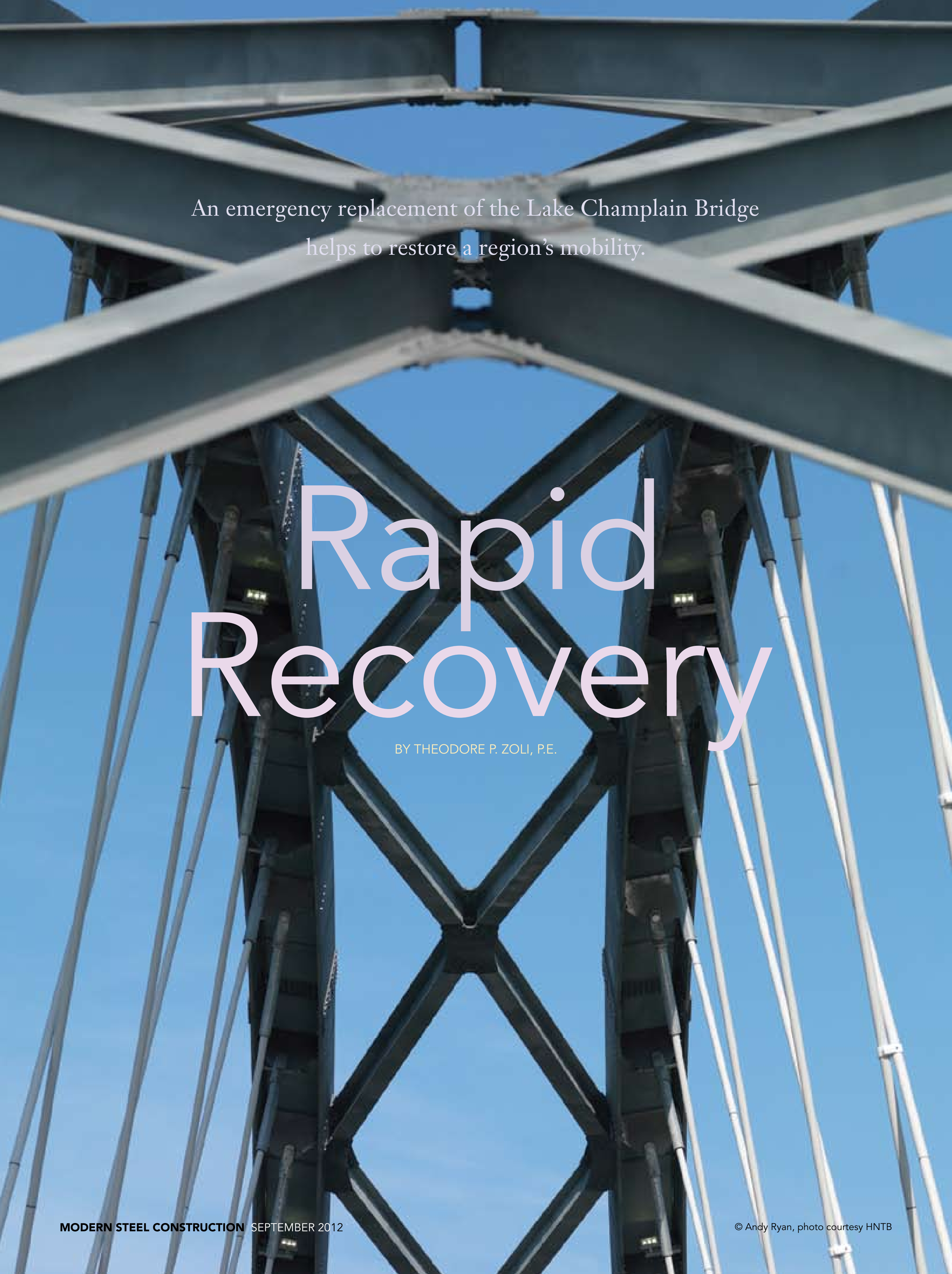

An emergency replacement of the Lake Champlain Bridge helps to restore a region's mobility.

Rapid Recovery

BY THEODORE P. ZOLI, P.E.

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▲ The center arch span was assembled on the shore of Lake Champlain and floated by barge two miles to the awaiting approach spans.

MUCH HAS BEEN WRITTEN about the emergency replacement of the Lake Champlain Bridge—from the unprecedented collaboration between the bi-state owners, New York and Vermont, and the Federal Highway Administration to the successful pre-assemble-and-lift scheme.

But little has been said about the critical role steel played in expediting the project. Without steel, the preferred design alternative would have been impossible, the expedited schedule and the budget would have been in jeopardy and the project would not have been able to deliver a critical new lake crossing in record time.

Closure Creates a Rift

The $76 million emergency replacement structure reaches 2,200 ft across a narrow spot in Lake Champlain, reconnecting the towns of Crown Point, N.Y., and Chimney Point, Vt. It was completed slightly more than two years after the former Lake Champlain Bridge was closed suddenly, due to concerns about the integrity of its piers. Declaring the bridge out of service was a stinging blow to residents' quality of life and their symbiotic economies, as there is not another roadway crossing in either direction for several miles.

Before Vermont and New York declared states of emergency and the New York State Department of Transportation (NYSDOT) closed the bridge on October 16, 2009, nearly 3,500 motorists a day relied on the 80-year-old structure as the most efficient route to work, school or even the grocery store.

After determining that strengthening and retrofitting the structure would neither be adequate nor cost-effective, NYSDOT and the Vermont Agency of Transportation (VTrans) announced on November 2009 that they would demolish the historic structure, construct a temporary ferry service and build a replacement bridge.

To expedite replacement of the existing bridge, NYSDOT developed a delivery strategy to complete design on a compressed schedule with the traditional, linear functions of final design, bid packaging, advertisement and permitting performed concurrently. The delivery strategy has been named "dynamic design-bid-build" (D2B2), and was executed at unprecedented speed for a bridge of its size. HNTB Corporation was the design consultant on the project and designed the modified network tied-arch bridge in just 10 weeks, delivering 95% of the plans and specifications in March of 2010. Detailing by Tensor Engineering began in April, and steel fabrication began in early July. The fabricator, High Steel Structures, began shipping steel to the jobsite in December 2010, and contractor Flatiron Construction erected the first girders in January 2011.

◄ The new Lake Champlain Bridge is built from 4,021 tons of steel.

Safer, Sustainable, Signature Steel Span

The new Lake Champlain Bridge (also known as the Crown Point Bridge) is composed of a total of eight spans with one network tied-arch signature span. The total bridge length is 2,200 ft, with seven approach spans, measuring up to 250 ft each, connected by a 402-ft-long, 8-story-tall steel arch span anchored by two 40-ft-deep rigid frame delta-leg girder assemblies. It was constructed with 4,021 tons of Grade 50W and Grade 70 HPS metalized steel.

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◀ Each cable has seven 0.6-in.-diameter strands.

▼ The arch is made from 902 tons of steel.

During the design process, HNTB presented six replacement alternatives during a rigorous six-day public involvement process, which began in December 2009. Of the six, four were steel structures and two were concrete. The decision to adopt a steel versus concrete superstructure had much to do with the project's fast-tracked schedule and the difficult winters typical of Upstate New York and Vermont. Cast-in-place concrete construction represented significant risks for schedule delays, given reduced winter productivity, making concrete alternatives that included balanced cantilever segmental and cable-stay bridge types less attractive alternatives. Both foundations and cast-in-place piers for the new bridge highlighted the difficulties inherent to cold-weather concreting in harsh climates. Extensive tenting and heating were required for multiple piers to maintain schedule, and significant construction activities continued year-round. The potential for lost days due to cold weather associated with a cast-in-place concrete superstructure would have negatively impacted the project schedule. Using steel and minimizing the amount of cast-in-place concrete work turned out to be the right decision, given that the significant approach superstructure construction activities took place throughout the winter months.

Not only that, but steel also had the public's support. After an unprecedented level of public input on the design alternatives, residents overwhelmingly voted in favor of the modified network tied arch. The new bridge, which had a form that was quite distinct from Charles Spofford's (the designer of the original bridge) continuous truss, still had an echo of the old bridge's form. The use of steel for both the old bridge and the new gives a sense of how differently the materials are used in new designs; trusses that in the past used thin plates, lattice work and gussets had given way to robust girders, delta frames and arch ribs.

Staying Informed

An accelerated design schedule is meaningless if it results in a bridge that is more difficult to fabricate, transport and build. Therefore, the construction strategy influenced the design. The basic design premise for fast-track construction is that the approaches and main span need to be fabricated and erected more or less simultaneously. This meant float-in and heavy lift construction for the arch was the only choice, and the approach delta frames would serve as a base for the crane for heavy lift operations.

On August 26, 2011, the center arch span, assembled on the shore of Lake Champlain, was floated by barge two miles to

▲ The center arch span was lifted 75 ft into place.

➤ Night work on the bridge.

Photos this page: © Trey Cambern Photography, photo courtesy HNTB

the awaiting approach spans and lifted 75 ft into place. Arch stability was a crucial part of the erection sequence, not just during float-in and lift operations but also during concrete panel installation, when the arch saw more deformation than at any other time and when its stability was most compromised. Flatiron worked with erection engineer, Erdman Anthony, to ensure a safe and fast erection before the remnants of Hurricane Irene struck the area less than two days later.

Given the complexity of the steel structure, the tight tolerances and the short schedule, there were concerns about fit-up during construction. However, within a few days after arch assembly, Flatiron requested daily steel shipments to keep up with erection activities. In all, construction and the lift went remarkably smoothly, a testament to High Steel's precision in fabrication and shop assembly.

An Evolving Arch

An evolution of a conventional tied arch bridge, the bridge uses inclined hangers that cross at least twice instead of vertical cables and hangers (the cable system is comprised of 44 cables per arch plane, and each cable has seven 0.6-in.-diameter strands). This crisscross pattern helps distribute the weight of the main span throughout the structure, making the overall system much more redundant; one or multiple cables can be damaged or lost without impacting the safety of the system. Additionally, the tie girder is designed as a built-up section and is therefore internally redundant. By making the tie girder composite with the longitudinally post-tensioned precast concrete deck, an additional level of redundancy is provided.

The use of multi-girder delta frames offers a unique and highly redundant way in which to support the arch. The arch bearings fall in between the outside two girder lines. Additionally, heavy lateral bracing connects all five girder lines, and a continuous transverse box beam connects the top of the delta frames. This arrangement provides for redundancy in that the system can tolerate the loss of any one of the delta frames through redistribution. The post-tensioned deck slabs also were designed to span the loss of a floorbeam at the limit state, such that all fracture-critical elements are eliminated.

To protect the majority of the bridge's superstructure from de-icing salt spray, HNTB designed generous deck cantilevers


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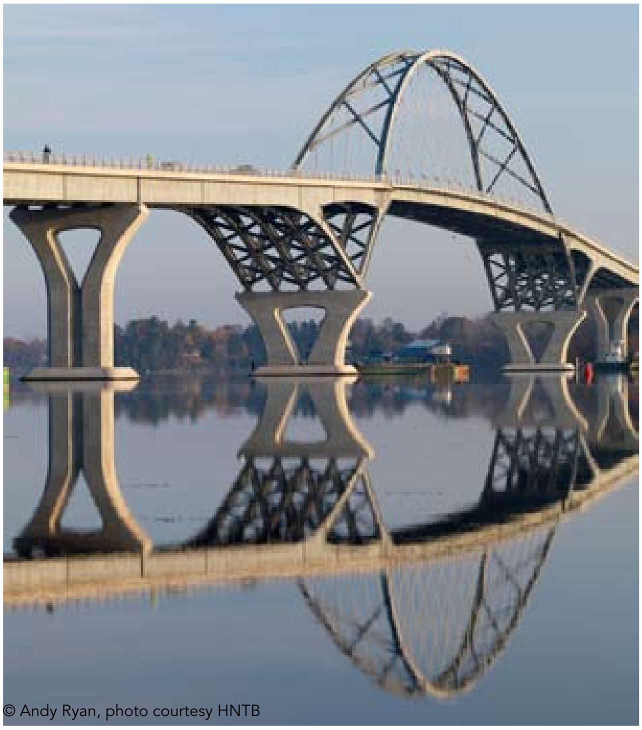
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▲ Crowds watching the arch lift.

◀ The completed bridge, once again linking both sides of the lake.

in the approach sections, adding extra thickness to the arch ribs in the above-deck superstructure and shop-applying a durable corrosion-protection system comprised of an 85% zinc and 15% aluminum thermal spray coating. These preventive measures are expected to extend the life of the bridge and reduce long-term maintenance costs.

It also is critical that the structural steel be readily accessible both for inspection and future maintenance. The tie girder is a bolted box with inspection access from the inside, and the arch and all approach girders are I-sections. The height of the arch rib above the deck was limited to allow for inspection access via man-lift.

The new Lake Champlain Bridge opened to traffic last November, and once again residents are able to drive across the lake—now via a safer, modern bridge with greater redundancy and a longer life. MSC

Owners

New York State Department of Transportation and Vermont Agency of Transportation

Structural Engineer

HNTB Corporation, Albany and New York City

Erection Engineer

Erdman Anthony, Mechanicsburg, Pa.

Steel Team

Steel Fabricator

High Steel Structures, Inc., Lancaster, Pa.
(AISC Member/NSBA Member/AISC Certified Fabricator)

Steel Detailer

Tensor Engineering, Indian Harbour Beach, Fla.
(AISC Member/NSBA Member) – bridge approaches
Candraft Detailing Inc., New Westminster, B.C.
(AISC Member) – bridge arch

General Contractor

Flatiron Construction Corporation, Firestone, Colo.