# Concrete Bridges in NEW YORK STATE

by Matthew C. Royce, New York State Department of Transportation

**NYSDOT started building prestressed concrete bridges in the 1950s.**

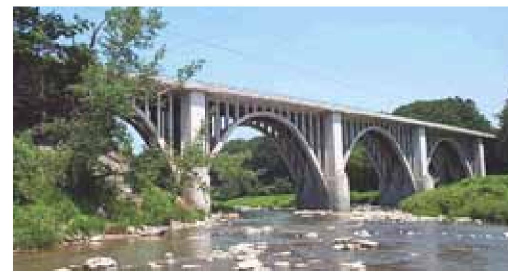
Concrete bridges play a significant role in the transportation infrastructure of New York State. Since the early part of the twentieth century, methods for both designing and building concrete bridges have undergone many changes. Generally, concrete bridges have served the state well. There are some cases, however, where early methods that were used have resulted in deterioration.

The New York State Department of Transportation (NYSDOT) has developed, and is currently using, technology in concrete bridge design and construction that will significantly reduce corrosion-related deterioration. NYSDOT is in the forefront of utilizing the latest advancements in concrete technology such as high-strength, high-performance concrete (HSHPC), self-consolidating concrete (SCC), ultra-high-performance concrete (UHPC), and internal curing concrete (ICC) for building concrete bridges that are more durable as well as cost effective.

## Reinforced Concrete Bridges

Many of New York State's aesthetically pleasing open spandrel concrete arch bridges built in the first half of the twentieth century are still in service today and, with proper maintenance, should continue to be for quite some time. One such structure, currently under rehabilitation, is Route 5 over Eighteen Mile Creek in western New York State. This bridge was completed in 1931 and is expected to have at least an additional 25 years of service life after the current rehabilitation is completed. Based on the proven durability and aesthetic appeal of these structures, NYSDOT continues to build reinforced concrete arch bridges whenever appropriate. Two such bridges, recently completed, are Route 5S over Wallkill and Route 30 over Minekill. Both bridges have cast-in-place, reinforced concrete arches and precast, prestressed concrete superstructures, made using self-consolidating HSHPC, above the arch.

Even though concrete arch bridges are both durable and attractive, they are relatively expensive to build. NYSDOT built a significant number of less expensive, yet still attractive, reinforced concrete earth-filled arch frame bridges for grade separations during the construction of parkways during the mid-twentieth century. These bridges have been very durable and the vast majority of them are still in service. Some of these bridges have been recently replaced with adjacent precast, prestressed concrete box beams with curved soffits to replicate the bridges they replaced.

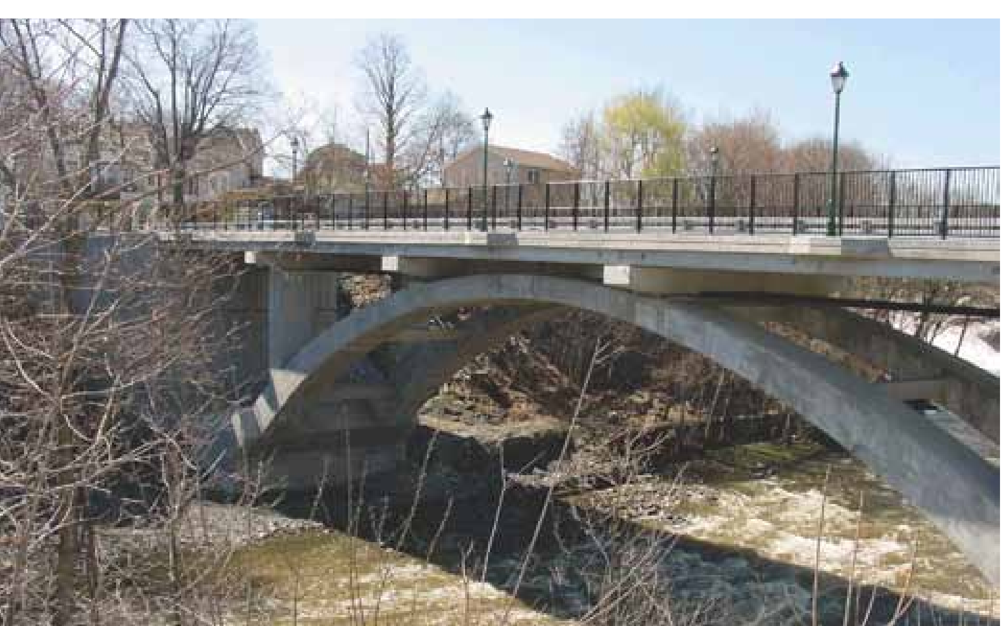


*Route 5 over Eighteen Mile Creek in western New York, is an open spandrel cast-in-place, reinforced concrete bridge completed in 1931. All photos: NYSDOT.*

## Prestressed Concrete Bridges

NYSDOT started building prestressed concrete bridges in the 1950s, with a few post-tensioned T-beam bridges. Most of the T-beam bridges have already been replaced due to the corrosion of the post-tensioning tendons—a result of insufficient grouting methods in use at that time. The grout, with high water content, left voids in the ducts, which when infiltrated by chloride contaminated deck drainage, led to significant corrosion of the post-tensioning tendons.

One remarkable bridge that was completed in 1960, I-81 over Oneida Lake, is worthy of special recognition. From the time of its completion until 2010, this bridge held the record for the longest main span in the world for a precast, prestressed concrete spliced girder bridge at 320 ft. The structure is in good condition overall except that the fascia girders have the bottom tendons corroded at locations where the girders were exposed to deck drainage. The weakened girders are being strengthened with external



*The Route 5S over Wallkill bridge uses cast-in-place, reinforced concrete arches with precast concrete spandrel columns, cap-beams, and a precast, prestressed concrete adjacent box beam superstructure. All precast components were made using self-consolidating HSHPC.*

*I-81 over Oneida Lake is a precast, post-tensioned concrete, spliced girder bridge. At 320 ft, it was the longest concrete spliced girder span in the world from 1960 until 2010.*

post-tensioning to restore their lost capacity. It is expected that this unique structure, which is eligible for entry into the registry of historic bridges will continue to be in service for many years after its rehabilitation.

Since the 1960s, pretensioned beams, predominantly adjacent box beam superstructures, have been the main stay for concrete bridges in New York; however, some AASHTO I-beam bridges were also built. Adjacent box beam bridges are a very cost-effective solution for short-to-medium span bridges; they are particularly appropriate where superstructure depth is limited. These superstructures also provide a smooth bottom, which is beneficial for stream crossings with low freeboard. Until the early 1990s, these bridges utilized a partial-depth shear key between beams. These shear keys had a tendency to crack and these cracks reflected through the deck, allowing drainage containing deicing chemicals to leak through joints between beams. This leaking led to the exposure of the sides and bottoms of the beams which, made with conventional concrete of the time, had relatively high permeability compared to today's HSHPC. Corrosive chemicals, mainly chlorides, seeped into the concrete resulting in corrosion of the prestressing strands and conventional reinforcement. A significant number of these bridges are nearing the end of their service life due to this problem and are expected to be replaced in the near future.

## Full-Depth Shear Keys and Enhanced Concrete

Starting in the mid-1990s, NYSDOT introduced full-depth shear keys between the box beams, along with higher transverse post-tensioning forces and increased reinforcement in the 6-in.-thick, cast-in-place concrete decks over the beams. These changes significantly reduced the reflective cracking above the shear keys. Even though some random shrinkage-related hairline deck cracking persisted, leakage through joints between the beams was practically eliminated. In order to further improve the durability of the prestressed concrete beams, NYSDOT started using high-strength (10 ksi), high-performance concrete for all precast, prestressed bridge components. This higher performance with regard to durability includes low permeability, better freeze-thaw resistance, and better scaling resistance. In addition, calcium nitrite corrosion inhibitor at a rate of 5.4 gal/yd$^3$ is being used in the concrete to improve the corrosion resistance even when some chloride manages to permeate the concrete. As additional insurance, all the beams are sealed with penetrating type sealers (silane) to stop any moisture and chloride intake by the beams via microcracks in the concrete. Overall, prestressed concrete beams used in New York today have the highest corrosion resistance possible, while still using conventional steel reinforcement.

NYSDOT has also been using high-performance concrete (HPC) in cast-in-place applications mainly for concrete bridge decks, for the last 15 years. The main focus is durability, rather than high strength. With the use of epoxy-coated reinforcement, along with HPC, these decks are expected to last much longer than decks with conventional concrete. One area of concern for NYSDOT, as well as many other states, is cracking of the concrete in the cast-in-place decks. NYSDOT has two ongoing experimental programs in this area. Based on various completed studies, the cause for these cracks has been determined to be tension in concrete resulting from restrained autogenous, drying, and thermal shrinkage.

## Deck with Internal Curing Concrete

NYSDOT has recently completed 10 bridge decks with ICC. The concrete mix is produced with a 30% substitution of fine aggregate with saturated lightweight aggregate fines which act as internal storage for moisture. The primary benefit of the mixture is that the autogenous shrinkage of concrete will be nearly eliminated and thereby reduce the tension in the hardening concrete deck. Evaluations on the decks built with ICC are ongoing and the results will be published at the conclusion of the study.

*Route 31 over Canandaigua Outlet shown during construction, is a precast, prestressed concrete deck bulb tee ready for the field-cast UHPC joints to be filled.*

*The twin, 2300-ft-long, I-390 bridges over the Genesee River, built in the 1970s, were some of the first cast-in-place, post-tensioned segmental concrete bridges in the United States.*

## Low Cement Concretes

Another study that has been started is on concrete decks made with lower cement content mixes. The lower cement content is made possible through the adjustment in large aggregate gradation with the primary benefit being lower heat of hydration. This reduces the tension in decks resulting from restrained thermal and drying shrinkage. That study is expected to be completed in 2 to 3 years, and should the results prove positive for both studies, development of concrete mixes incorporating the beneficial aspects of both approaches is anticipated.

## Accelerated Bridge Construction

NYSDOT is at the forefront of developing enabling technologies for accelerated bridge construction (ABC). The use of precast concrete bridge elements is an efficient way to accelerate bridge replacements; however an area of concern is the durability of the joints between the members. NYSDOT, with the assistance of the Federal Highway Administration and the concrete industry, has developed and tested joints using UHPC. These joints need only be 6 in. wide since the reinforcing bars up to size No. 6 can be fully developed within a joint of that size. These joints are also highly durable and crack resistant. The first use of the UHPC joint was for the superstructure for Route 31 over Canandaigua Outlet in Lyons, N. Y. With a short schedule, this project used deck bulb tees (DBT) with UHPC joints between them. It was completed in 2008 (for more information, see *ASPIRE*™, Fall 2009, page 28). There are two ongoing projects utilizing DBTs and UHPC joints: Staten Island Expressway over Fingerboard Avenue and Route 248 over Bennets Creek.

Route 23 over Otego Creek used UHPC in joints between precast, prestressed concrete full-depth deck panels. This is another beneficial application this technology. The project was completed in 2009. UHPC joints eliminated the need for the commonly used longitudinal post-tensioning of the deck panels. Precast concrete decks with UHPC joints and haunches are an alternate to cast-in-place decks for some of NYSDOT's upcoming bridge replacement projects.

## Segmental Concrete Bridges in New York

The 2300-ft-long, I-390 twin bridges over Genesee River were among the first post-tensioned segmental bridges in the country. These cast-in-place segmental bridges were built using the balanced cantilever method during the 1970s. The two bridges are performing very well with minimal maintenance. NYSDOT continues to use segmental concrete bridge construction where appropriate and cost effective. In addition to the concrete segmental structure for the JFK light rail link built under public-private partnership, NYSDOT completed the Marcy Avenue ramp to Williamsburg Bridge in 2001 and the Roslyn Viaduct in 2011. For the Roslyn Viaduct, precast, segmental match-cast concrete construction was used for the piers, in addition to the balanced cantilever superstructure (see *ASPIRE* Fall 2009, page 32). Both superstructure and substructure used self-consolidating HSHPC with corrosion inhibitors. The grouting of the post-tensioning ducts, performed by American Segmental Bridge Institute-certified technicians, under stringent quality control-quality assurance and using pre-packaged, no-bleed grout is expected to perform well, long into the future.

*The Roslyn Viaduct used precast concrete segmental construction for both piers and superstructure. HSHPC was used for all precast concrete components.*

## Conclusion

In general, concrete bridge building in New York State is a thriving industry. The concrete bridges that are being built today are focused on durability. Accelerated construction, at reasonable cost and with equal or better durability compared to conventional construction, is another area where the NYSDOT has made significant strides.

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**For more information on New York State's bridges, visit www.nysdot.gov/index.**