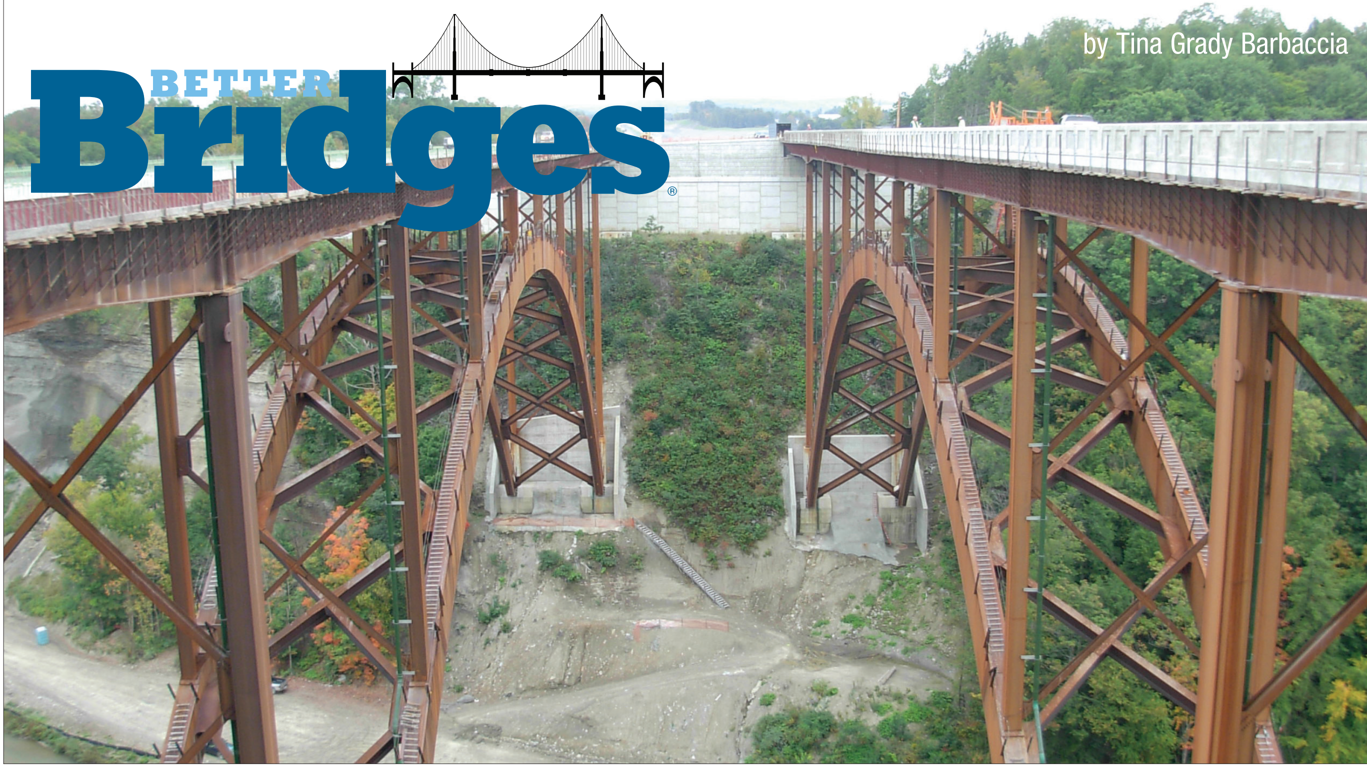
BETTER Bridges®

by Tina Grady Barbaccia



***The arch erection process** for this bridge used a complex tie system that used adjustability as its key. Three ties were used: An anchorage tie, which connects the top of the permanent concrete pier bent to the anchorage, and two other ties.*

Arch Artistry

The Route 219 deck arch bridge over Cattaraugus Creek in New York used a complex tie system, a massive crane and a creative erection process.

Adaptability and adjustability. These are critical parts of survival in nature and oftentimes for success in the real world.

For the construction sequence of a deck arch bridge in New York, these were also the keys to the erection of two 460-foot-long twin arches – part of a 750-foot-long bridge over the Cattaraugus Creek. The twin arches are part of a larger $100 million, 4.2-mile highway expansion and improvement project of new construction on Route 219 south of Buffalo, N.Y. The entire Route 219 was designed in 12 sections, four of which are complete, from West Seneca to Springville. The current section under construction begins at Route 39 in Springville and extends to Peters Road in Ashford.

The overall project is intended to address safety and operational deficiencies and the increased truck traffic along the corridor and to enhance regional and statewide economic development. The roadway consisted of two lanes in each direction and 11 bridges, including the one over the Cattaraugus Creek.

Using a unique approach to arch bridge construction, engineers designed an erection sequence where permanent bridge columns on each side of the Cattaraugus Creek supported the arches during erection. The arches were held in place by ties attached at two points on each arch. The key to the success of this erection process was the adjustability of the ties.

"No doubt, the adjustability was key," notes Stephen J. Percassi, P.E., project engineer for Erdman Anthony, the company who assisted Woodbury, N.J.-based general contractor Cornell & Company's in-house engineer with the unique bridge erection process. "Without it, this procedure wouldn't be possible. We had to have enough adjustability to effectively transfer all the weight from tie No. 2 to the arches so they could act like arches. Three ties were used: An anchorage tie, which connects the top of the permanent concrete pier bent to the anchorage, and two other ties.

"The other two ties – tie No. 1 and tie No. 2 – bear all of the weight," Percassi says. "We essentially hang all the weight of the arch on them." The arch was broken into five pieces per half. Each piece was added sequentially, which in turn pulled on tie No. 1 and No. 2, which then pulled on the concrete anchorage/reaction block. "We designed this system so it only needs one arch tie at any given time," Percassi explains. "It never uses both simultaneously. We designed it this way for adjustability."

Tie No. 1 was fixed in length and had a hinge at about the one-third point in its length. Tie No. 2 was "the workhorse of the whole system," Percassi says. Tie No. 2 was designed to have 12 inches of adjustment. When the erector – the Erdman Anthony/Cornell & Company team –

installed it, everything was hooked on the tie, he says. "The adjustability of tie No. 2 allowed us to purposely shorten it, erect the arch higher and lower it later," Percassi says.

This is extremely significant, Percassi points out, because when tie No. 2 was intentionally shortened, it rotated the arch backward. This was possible because tie No. 1 had a hinge on it.

"Tie No. 1 can't take the compression because it has a hinge on it," Percassi says. "The hinge in tie No. 1 allows 100 percent of the force to be transferred to tie No. 2." At this point, tie No. 1 is not doing anything. After the installation of tie No. 2, tie No. 1 isn't needed anymore."

After all of five segments that the arch was broken into have been installed, the largest load has been produced. "Once the fifth piece was added, it produced the largest load – 515,000 pounds – on tie No. 2."

Not according to the 'original' plan

This unique process wasn't part of the original plan. The New York State Department of Transportation (NYSDOT), owner of the bridge and engineer of for its design, initially recommended that a temporary tower be erected to support the arches during construction. The contractor, Akron, N.Y.-based Cold Spring Construction, subcontracted with Cornell & Company to erect the twin 750-foot arch structures. Cornell then hired Erdman Anthony to act as the erection engineer and to assist with putting together the erection procedures and help secure approval from NYSDOT.

"As part of the design process, we suggested an erection procedure," says Art Yannotti, director of the Structures Design Bureau for NYSDOT. "For the most part, we don't usually put together a construction sequence on the design plans. It's up to the contractor to decide how to erect it and submit to the department [NYSDOT] for approval."

However, because of the complexity of the bridge construction, Yannotti says, NYSDOT put together a possible construction sequence. The contractor submitted its plan and then hired Erdman Anthony. "The contractor had found a better way of doing it," Yannotti says. With the help of Erdman Anthony, an alternative design was used to save both time and money.

In short, the modified design increased the six nearly equal-length arch segments to 10 segments, with two initial large segments that were supported by the arch ties and three much smaller segments. Essentially, until connecting the arch at the crown, much of the arch hung like a cantilever over the creek.

Once both sides of the arch were erected, the 18-inch gap at the crown was closed by carefully releasing tension on the arch ties. The land end of the arches was attached to a hinged arch bearing, which allowed them to slowly rotate into place as the tension on the arch ties was loosened.

"This was where the importance of the adjustability of tie No. 2 came into play," Percassi says. "It's like standing on top of a diving board. It deflected downward—cantilevered—dangling over the gorge." The downward deflection is typical of cantilevers, but it's also what complicated the overall system even more because it required an additional temporary pin at the crown of the arches to allow the two halves to be leaned into one another.

When the top of the arches touched, a temporary 4-inch flange pin was inserted at the top flange. Then a permanent crown pin was inserted in the middle and the temporary pin was eventually removed. "The middle pin is the one that remains for the duration of the structure."

An enormous crane

In addition to adjustability, one of the other most essential parts of the modified design was the use of a unique crane configuration by Cornell & Company. The project used a Manitowoc 888 ringer crane with 275-foot boom and a 140-foot, 10-degree offset jib. This enormous crane configuration is only one of about five in North America, according to information currently available to Erdman Anthony and NYSDOT.

The crane had 1.4 million pounds of counterweight hanging off the back of it. The outside diameter of the crane's ring was 51 feet, 2 inches. Use of this size crane and the placement is different than the original suggested NYSDOT construction sequence in that only one enormous crane was used instead of several cranes placed on the structure itself.

"This was needed because of the location at Cattaraugus Creek," explains Percassi. "We found it easier to keep the crane on the edges of the gorge and erect the arch from halfway across the top."

Once the crane was in place, a crane pad (developed by contractor Cold Spring Construction) had to be engineered. The crane was used to set the pieces from behind the abutment so special a crane pad had to be built. This process took a significant level of design because it is immediately behind the abutment, Percassi points out.

"When you load the crane with the heavy pieces [the crane] is picking up, it will in turn load the abutment," Percassi notes. "We needed to ensure the crane and the abutment

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The erection of the Route 219 Bridge *over Cattaraugus Creek project used a unique crane configuration. A ringer crane with 275-foot boom and a 140-foot, 10-degree offset jib with 1.4 million pounds of counterweight was used.*

Photo courtesy of New York State Department of Transportation

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were to remain stable."

Solid rods were drilled into the earth and into the bedrock and anchors were put in place. Drilled tiebacks, installed by subcontractor Herbert F. Darling, were used to develop a concrete anchorage that was able to resist the pullout force from the erection procedure. Additional piles also were drilled to support the concrete anchorage, also referred to as reaction block.

"The effects of the erection procedure will try to pull the tiebacks out," Percassi explains, so Cold Spring Construction conducted load testing. "The tiebacks were proof tested to 133 percent of the design load and locked off at 5 percent of it. An additional 40,556 pounds of a mechanically stabilized earth system, or MSES, was required for crane support. The crane was set up on 34 support pedestals – each pedestal was 20.83-square-feet – with 14 layers of MSES geogrid reinforcement behind the bridge abutment atop the gorge.

"The most important thing is that the crane pad is engineered to resist the loads induced by the crane," Percassi points out. The crane pad was engineered to accept 13,720 psf of applied stress.

Careful calculations

Once the crane pad was set up and the crane put in place, the erection of the steel started. With plans to use as few temporary pieces as possible, the permanent structure was used in the arch erection. Percassi says that only about 12 temporary pieces were used per arch.

The temporary pieces – or ties – were installed. Three ties were used. One of the ties was the anchorage tie that connected the top of the bent to the concrete anchorage/reaction block. The other two ties – tie No. 1 and No. 2 – essentially carried the weight of the arch to restrain it from falling into the gorge. The anchorage tie resisted the loads from these two ties.

"Instead of cabling the tiebacks, they used tiebacks out of structural steel and then able to make adjustments by threaded rod adjustments in tiebacks instead of adjusting the cable to try to close the arch," Yannotti says. "It's a lot easier to make adjustments in the vertical method than in the traditional method. They correct the initial position because of the amount of adjustment in the cable was limited. This allowed them the flexibility of adjusting the arch itself so it was easier to make adjustments in erection procedure itself."

Percassi adds that careful calculation went into confirming the amount of adjustability required. "We would have otherwise had to find another method to transfer the rest of the load to the arches," Percassi says. "This would have added more time and cost. It's very important to make sure you account for as many unknowns as possible."

The bridge itself has been completed, but it is not yet open to traffic. Currently, the ETA for opening the bridge is at the end of this construction season.

Erection of the bridge began in April 2008. Prior to this, quite a bit of substructure had to occur before the erection process could take place. The arches were completed in Fall 2009 with a concrete deck. The erection was finished in Spring 2009, and the deck was placed in the Summer/Fall of 2009. ❖

Turn the page for ADDITIONAL information on this story - found only in this *Better Roads* Digital Edition!

For more information from the NYSDOT about this project, go to *http://bit.ly/Rte219project.*

Location, location, location

The New York State Department of Transportation could have chosen to build a bridge with a deck arch, which goes below the roadway, or a through arch, which goes above the roadway. It chose the deck arch option. Why?

Location, location, location. The valley over which the bridge was built it very deep — more than 200 feet above the Cattaraugus Creek. "We had all kinds of vertical clearance," says Art Yannotti, director of the Structures Design Bureau for the New York State Department of Transportation (NYSDOT). "Because the deck arch reaches so far down beneath the structure, we didn't have high piers." Technically, there are no piers, per se, on the structure.

"We chose a deck arch because the site lent itself to it," Yannotti says. "An exposed arch is a good foundation for thrust blocks, the concrete blocks that support the arch. You want a rock material for most arches. We had that available at the site."

Yannotti says if the NYSDOT were to construct another bridge with a deck arch, knowing what it knows now, it would most likely propose an erection process similar to the one Erdman Anthony designed.

[Top 4 Takeaway Tips]

Art Yannotti, director of the Structures Design Bureau for the New York State Department of Transportation (NYSDOT), offers these four bits of advice as the most important takeaways his agency learned from this project.

1. **Construction sequence is important.** Constructability is always important. It is of more important [than usual] in this type of structure. "You have to think about constructability when designing the details," Yannotti says. "It's critical to think about how [the bridge] will be put together.
2. **Fabrication of the steel.** This can be very complex, Yannotti says. "Steel box sections were used for the rib," he says. "They are large enough to be inspected from the inside." But this also made the box sections difficult to fabricate because of their geometry in order for them to maintain the necessary tolerances and to be square and plumb. "It's difficult to weld a box shape like this," Yannotti says.
3. **Inspectability.** It's crucial to have a structure that may be accessed for inspection later on. The box sections on this bridge allow for easy inspection because a person can fit inside of them.
4. **Minimize fatigue.** "Historically, there have been some problems in deck arch bridges with the columns that sit on top of the arch and support the girders when you get to the crown of where the arch comes close to the roadway," Yannotti points out. "The columns on some deck arches have been prone to fatigue cracking because the movement of the structure is concentrated in a shorter length." However, Yannotti says, on this project, the crown of the arch wasn't brought that close to the roadway. "We left the crown of the arch lower," Yannotti says. "We did not approach the deck as closely to the center columns were longer. By doing this, we have some increased fatigue resistance."

FastFact

The project used about 25,000 metric tons of tire shreds encompassing 2.5 million used tires. These tire shreds were used to construct selected embankment areas.