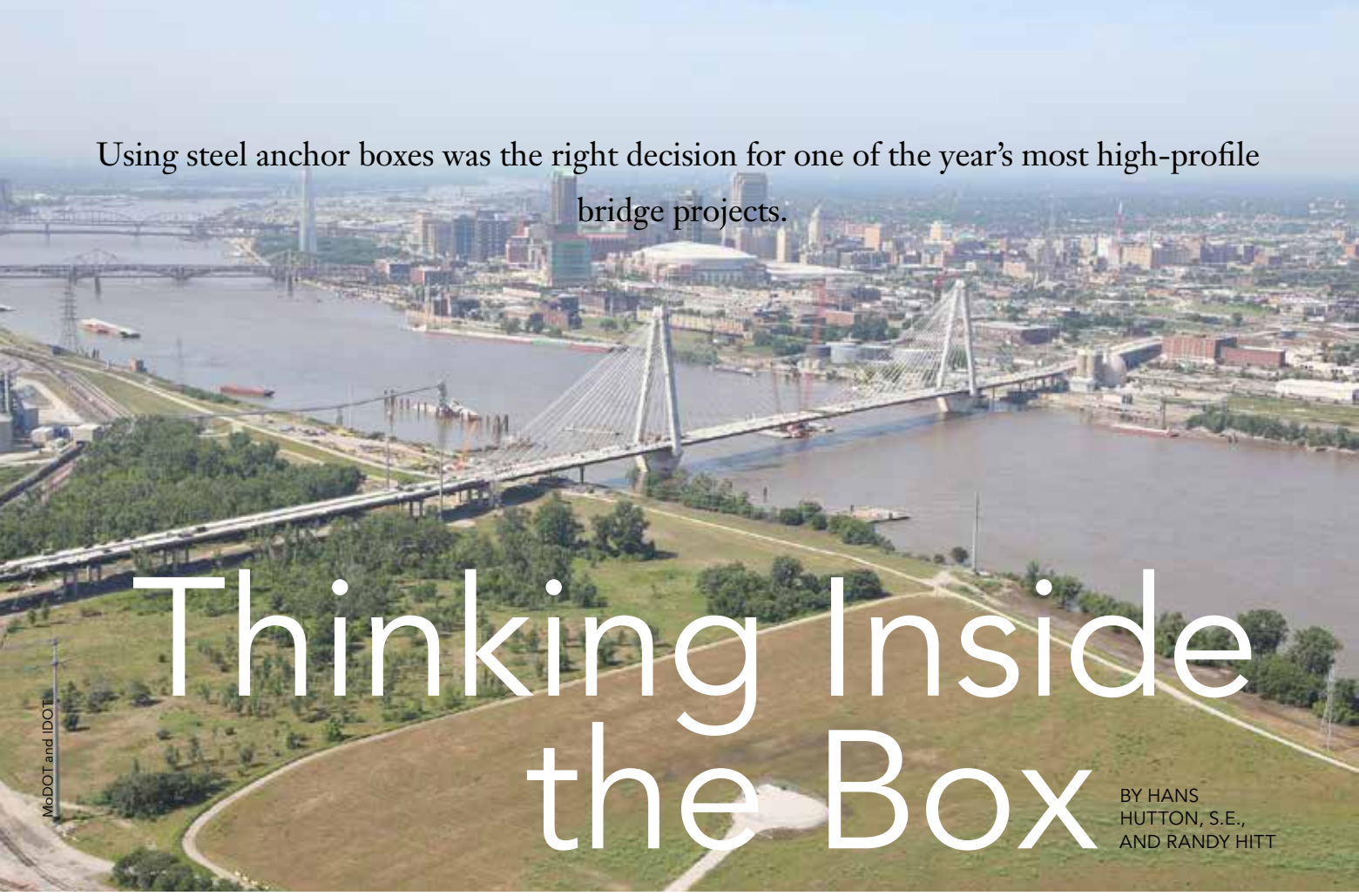
Using steel anchor boxes was the right decision for one of the year's most high-profile bridge projects.



MoDOT and IDOT

Thinking Inside the Box

BY HANS HUTTON, S.E., AND RANDY HITT

THERE WAS MUCH DEBATE over the permanent name for what was once known as the New Mississippi River Bridge.

The bridge connects Illinois with Missouri over the Mississippi River near downtown St. Louis, and politicians on both sides of the river had different ideas for the name. The Illinois side wished to honor military veterans while the Missouri side wanted to name the bridge after the St. Louis Cardinals' legendary outfielder and first baseman Stan Musial, who died in January. In the end both sides won, and this past summer the bridge was officially named the Stan Musial Veterans Memorial Bridge (SMVMB).

The $230 million bridge is being built to alleviate traffic on the nearby Poplar Street Bridge, which carries Interstates 55, 64 and 70 as well as U.S. 40, and will run between downtown St. Louis and East St. Louis, Ill. The plan is to reroute I-70 traffic to the new bridge, which will accommodate two lanes in each direction, with the ability to expand to three lanes. The long-term plan is to build another, adjacent bridge. When completed in February, it will be the third-longest cable-stayed span in the United States.

Hans Hutton (hhutton@hntb.com) is a chief engineer with HNTB Corporation. **Randy Hitt** (randy.hitt@modot.mo.gov) is a project director with the Missouri Department of Transportation.

A Different Type of Box

HNTB Corporation, the bridge's structural engineer, created a design that employed steel anchor boxes inside of the pylons for the stay cable anchorages instead of using formed concrete corbels. The use of steel anchor boxes eliminated the need for complex forming of concrete inside the bridge's delta-shaped pylon legs. Ultimately, the use of steel saved time, reduced cost, increased accuracy in the tight tolerances of the cable geometry and reduced the amount of post-tensioning needed around the perimeter of the pylon legs.

The decision to use steel anchor boxes is a classic example of how recognizing contractors' challenges can inform design. While working on two previous cable-stayed bridges—the Cape Girardeau and Greenville Bridges—HNTB used concrete corbels to anchor the cables inside the towers. Both projects were highly successful, but it was obvious during construction that the tedious and labor-intensive forming and post-tensioning involved with creating the corbels slowed contractors' pace. As good engineers are always seeking feedback and looking for ways to improve the process, HNTB opted for a more efficient approach with the SMVMB.

Certainly, steel anchor boxes have been used on other bridges, but HNTB had never before used them to anchor stay


W&W/Afco

The steel anchor boxes ranged from 6 ft to 9.5 ft tall.

The new bridge will alleviate traffic on the nearby Poplar St. Bridge.

The bridge carries I-70, with two lanes in each direction.

There are anchor beams within each steel anchor box.


W&W/Afco


© Tim Parker Photography, photo courtesy HNTB Corp.

cables on their cable stayed bridge designs. Because the Illinois and Missouri Departments of Transportation (IDOT and MoDOT) have a very aggressive schedule for this bridge, the HNTB design team believed that steel anchor boxes would be appropriate for the project.

HNTB began design in July 2008 and completed its baseline design, including the use of steel anchor boxes, in July 2009. That November, the highway departments awarded the construction contract to a joint venture of Massman Construction, Traylor Brothers and Alberici Constructors.

Slow to Change

As any contractor will tell you, whenever you have to stop and change a process, progress slows down. Creating concrete corbels requires the building team to stop and switch from forming the lifts of the tower to building forms for the corbels. Concrete also would have required the contractor to form in the air, as the towers for the bridge extend 400 ft. above the water. With steel anchor boxes, however, the team could start at deck elevation with a hollow tower and continue all the way to the top with the same basic shape.

"HNTB designed each box as an individual piece with a vertical dimension from 6 ft. to 9½ ft.," said Dennis Noernberg, bridge detailing manager for W&W/AFCO Steel, which fabricated the steel for the bridge. "That allows for a continuous shaft of boxes from the lowest cable to the cable at the very top of the pylon."

Within each box is an anchor beam. While other designers have typically stipulated welding the anchor beams to the boxes, HNTB designed it so that the anchor beams were bolted to the boxes. "This was a good option, a lot more predictable from a fabrication standpoint," Noernberg said. "We were able to drill holes in the box walls for the anchor beams with digitally controlled equipment, increasing accuracy."

Additionally, there is increased potential for human error when fitting large steel plates inside the boxes, setting them at the correct angle and welding them in place, he explained. "The extensive welding required can actually deform the box and cause you to be out of tolerance. The bolted option was definitely more straightforward and more predictable."

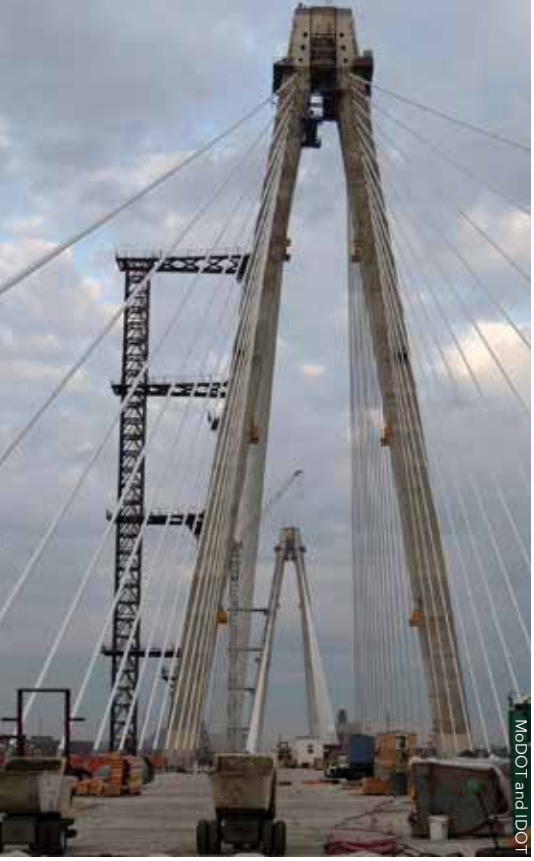
HNTB also used the bolted option to attach the cable anchorage to the edge girder at the deck level. "For the fabricator, it's not as risky as a welded connection," Noernberg said. "The bolted option made it easier to maintain the required tolerances since welding distortion is eliminated."

Tom Tavernaro, project manager for the joint venture contractor, agreed that the steel anchor boxes were definitely a better solution.

"They help maintain the geometry of the stay cables within 0.3 degrees of the theoretical vectors," he said. "The reference planes for the anchor boxes were tied to the anchor geometry in the fabrication shop. After we set the boxes in place, we had to adjust them to the target coordinates, but that's much easier to do than trying to align concrete forms down to the tolerances you need."

"Steel anchor boxes were a better solution than formed anchorages, and they saved us time in the congested, upper portion of the pylon," he added.

"Steel is a good solution because it makes construction of the pylons go faster," Noernberg said. "Since the steel boxes are actually the form for the inside of the pylon wall, they don't have to form inside with some other method."



▲ Tower construction took approximately 10 months.

▲ All of the structural steel elements on the bridge are made of weathering steel.

In addition, all of the structural elements on the bridge are made of weathering steel, which has a 100-year design life and saves on cost of maintenance, materials and interruption to traffic.

Above Water

Bridge projects often require workers spend their work hours off the ground and over water. Here, steel anchor boxes provided another advantage: minimizing the work the construction team had to perform in the air. "We were able to pre-tie the rebar and anchor box assemblies on a barge working at a height of 20 ft rather than at several hundred feet" Tavernaro said. "The least amount of work you have to do at the top of the tower, the better off you are."

Tower construction was about a 10-month process, which went quickly for several reasons, according to Tavernaro. "We built plenty of templates to get the prefabrication done off of the critical path, and we were fortunate to have equipment

▼ Joining the two sections over the Mississippi River.

▼ The bridge is exandable to three lanes in each direction; the long-term plan is to build an adjacent bridge.

The Illinois and Missouri sections, before being joined in the middle.

The project uses 8,000 tons of structural steel in all.

that allowed us to pick up ganged assemblies of these boxes that weighed upwards of 70 tons."

The joint venture contractor worked with W&W/AFCO to gang together the 6-ft-tall boxes in the shop. "We adjusted the tower lift heights on the plans to where they coincided with the tops of the anchor box tops," Tavernaro said. "We set a gang of two or three boxes and basically poured the whole thing in. We could tie all the rebar and the anchor box and everything for a lift on a barge and then set it all in place in a short time period."

The project used Massman's barge-mounted pedestal crane, a Manitowoc 7000 ringer, which has a 350-ton capacity, 400 ft of boom and 40 ft of jib. "If we didn't have that equipment, we would have had to hoist smaller assemblies or build each one individually in place," Tavernaro said.

Overall, the project required W&W/AFCO to fabricate 8,000 tons of steel, a significant project for the company. "Any fabricator will tell you that the cable stayed bridge is one of the more complex to fabricate," Noernberg said.

A cable anchorage.

▲ A view from one of the 400-ft-tall pylons, with the Illinois and Missouri sections connected.

The delta-shaped pylons require all cables to strike the deck at both vertical and horizontal angles, which means essentially working in three dimensions and with tighter tolerances. "It's very complex work that demands a high level of skill for people in the shop," Noernberg said. "We did it successfully so that it all went together very well in the field." MSC

Owner
Illinois Department of Transportation and Missouri Department of Transportation

General Contractor
Massman, Traylor, Alberici, a Joint Venture

Structural Engineer
HNTB Corporation, Kansas City

Steel Team

Fabricator
W&W/AFCO Steel, Little Rock, Ark. (AISC Member/NSBA Member/AISC Certified Fabricator)

Detailer
Tensor Engineering, Indian Harbour Beach, Fla. (AISC Member/NSBA Member)