MANHATTAN BRIDGE REHABILITATION

Steel Is the East River Workhorse

Given the well known resiliency of structural steel, the Manhattan Bridge will stand for at least 75 more years before another reconstruction of this scope goes up for consideration.

Previous 80,000 vehicles and 320,000 transit riders cross the Manhattan Bridge every day.

Above The bridge's suspender cables were replaced.
Facing The rehab replaced the span's floor beams and decking.

Previous and this page: NYC DOT Bridges

NYC DOT Bridges

The Manhattan Bridge has repeatedly been described as the workhorse of the East River spans. So it was no surprise that, after nearly a century of service, the crossing was found to be in dire need of repair. In response, the New York City Department of Transportation (NYCDOT) launched a bold 15-phase rehabilitation effort that began in 1982 and, with completion expected in 2013, is nearing $1 billion in costs. As part of this effort, the bridge's four stiffening trusses have been reinforced, the decking and bearings have been replaced, and the main cables have been re-anchored, work encompassing thousands of tons of structural steel. Now, owing to the material's enduring strength and flexibility, the 1,470-foot main span of the Manhattan Bridge is ready to continue carrying the 80,000 vehicles and 320,000 mass transit riders that cross it everyday well into the future.

Originally intended to relieve the Brooklyn Bridge's throngs, the Manhattan Bridge was the first East River crossing to accommodate vehicles as well as subways traveling in both directions when it was completed in 1909. But not all firsts equate to bests. Among the designers of the Manhattan Bridge was bridge engineer Leon Moisseiff, known for his work on deflection theory and subsequently designer of many other famous spans employing this concept. The concept asserts that the stiffness of a bridge deck could be decreased with more dead load, meaning the longer bridges were the more flexible they could be. Thus stiffening trusses could be minimized for longer, inherently heavier bridges in Moisseiff's view, and this innovative thesis formed the underlying principal of the East River span. But in the early 1900s, deflection theory wasn't advanced enough to accommodate the complex conditions of the Manhattan Bridge: For reasons that are now unexplainable, Moisseiff decided to run the subway train tracks along the outer edges of the roadway, instead of running them down the middle. As a result, the subway cars exerted incredible torque on the structure. The workhorse, it turns out, was a bucking bronco—its deck tilting as much as eight feet under the weight of a loaded train, forcing suspension cables to shift relative to and abrade against the steel trusses. To find a solution to the problems posed by Moisseiff's design, NYCDOT hired Weidlinger Associates as designer and structural engineer on the rehabilitation project. Assessing the situation, the firm worked out a scheme to brace the bridge's under-designed lateral stiffening system with new structural steel members, thus creating a "torque tube," which along with re-decking the bridge and re-anchoring its cables ensured that this vital city artery would not deflect more than three feet.

The torque tube plays the vital role in minimizing deflection. Weidlinger reinforced the lower lateral bracing, located beneath the bridge's lower deck, and installed all-new lateral bracing underneath the upper deck (the original had been removed in the 1950s due to visible cracking), forming a four-sided shape that led to its "tube" designation. The engineers also added 16 end frames to the towers and anchorages in order to better transfer twisting load into vertical load. The new steel reinforcing and bracing members are attached to the trusses via new, larger gusset plates, which vary in size depending on the forces present at the connection, but are never less than ¾ inch in thickness. Although slightly different in appearance from the old lateral bracing, the new steel members are barely visible to drivers. All of the new lateral members are built-up T, reversed U, or H shapes, with the flanges welded to the stem. All connections are made using A325 high strength bolts. The cost of this phase of the work represented approximately 10 percent of the total budget. The larger proportion of project's steel contract was devoted to deck replacement. Divided into separate contracts, crews ultimately replaced approximately 1,600 roadway and subway track floor beams, and many more stringers. The existing roadway beams were built-up, riveted members, the ones replacing them are welded plate girders of the same size, but with improved section properties and stronger Grade 50 type steel. The new members are connected to the trusses with bolted connection angles using high strength bolts. But not all floor beams beneath the upper roadway were replaced, meaning that the bridge still hosts some older patch repairs made to counter section loss. Indeed, whole chunks of the structure had disappeared as a result of long exposure to the elements, corrosion from pigeon droppings, and an overall neglect that characterized New York City's understandably laissez-faire approach to infrastructure during the fiscal crisis of the 1970s. These cavities and weaknesses were plugged over time with steel plates fastened via high-strength bolts.

In the case of the bridge's signature decorative work, which includes canopy structures, handrails, and informational plaques, "we paid attention to the original architectural details that are evident and unique to the bridge," Terrence Daly, senior vice president of general contracting firm Koch Skanska and steel erector, says of the castings that were undertaken. "Some of that work is so unique for a contractor that it's difficult to price correctly. It's not something we do as a normal course of business."

Whereas the ornamental metal work demanded a historically respectful approach, stiffening measures permitted an injection of high technology. For all members, ASTM A588 Grade 50 steel, which has atmospheric corrosion resistance properties, replaces older Grade 36 material. And in the approach spans, the bearings that sit on masonry piers have been replaced with Teflon-coated multi-rotational bearings that have a very low friction coefficient. Installing the new bearings was a feat in and of itself. After installing a temporary steel frame underneath the crossing's trusses, Koch Skanska closed the bridge to subway and car traffic, then hydraulically lifted the bridge a half-inch, clearing enough room to switch out the deteriorated load bearings.

One final aspect of the rehabilitation efforts involved meticulously removing the bridge's lead paint and recovering the structure with safer and more durable epoxy coating—in the bridge's famous blue, of course. Still, Brian Gill, the engineer in charge of the project for NYCDOT, emphasizes that better defenses do not preclude more regular maintenance. Each maintenance schedule depends on the component, he says, although, say, spot-patching the paint—one of a bridge's best barriers against corrosion—can happen anytime. But given the well-known resiliency of structural steel, he expects that the Manhattan Bridge will stand for at least 75 more years before another reconstruction of this scope goes up for consideration. **M**

NYC DOT Bridges

Facing and above Rehabilitation efforts included restoring the bridge's signature ornamental ironwork.

MANHATTAN BRIDGE REHABILITATION

Owner: **New York City Department of Transportation**, *New York, NY*
Designer and Structural Engineer: **Weidlinger Associates**, *New York, NY*
General Contractor: **Koch Skanska, Inc.**, *Carteret, NJ*
Structural Steel Fabricator: **American Bridge Manufacturing**, *Coraopolis, PA*
Structural Steel Erectors: **Northeast Structural Steel**, *Mt. Vernon, NY*;
Koch Skanska, *Carteret, NJ*
Miscellaneous, Architectural, and Ornamental Metal Erectors:
Northeast Structural Steel, *Mt. Vernon, NY*;
Koch Skanska, *Carteret, NJ*