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A Bridge Too Fat

By SEWELL CHAN

The Bronx-Whitestone Bridge has a weight problem.

Over the decades, the 65-year-old suspension bridge has been bulked up to make it more stable. But now engineers have decided that it has grown too beefy.

"We put this bridge on a diet," said Michael C. Ascher, the president of M.T.A. Bridges and Tunnels, an arm of the Metropolitan Transportation Authority. "Here's a bridge that's 65 years old. It got a little heavy around the midsection. Just like with the human anatomy, as you get on in years, lean is better. In this case, instead of putting an extra strain on your heart and other organs, it's putting a strain on the supporting structure, the skeleton, of the bridge."

When the work is completed a year from now, the steel and concrete bridge will have shed 6,000 tons, or one-quarter of its total suspended weight. Engineers say the decreased weight will reduce the strain on the bridge's steel cables, make it more durable and lengthen its life by decades, if not centuries.

Last year, workers completed the removal of steel trusses that were installed on each side of the bridge in 1946, after the notorious collapse of a bridge in Washington State. In June, they will begin replacing the bridge's concrete deck with a lightweight steel version that is being built in Brazil.

The project to decrease the bridge's load, which follows years of wind and stress tests on laboratory models, is possible because of advances in aerodynamic design.

The Bronx-Whitestone Bridge has long been known for its slim and graceful profile. It was built in less than two years to serve visitors to the New York World's Fair in Flushing Meadows-Corona Park and it opened to traffic on April 29, 1939 - the day before the start of the fair.

Stretching 2,300 feet between its two towers, the span was the fourth longest in the world. At the ribbon-cutting, Robert Moses, the highways and parks czar who oversaw the bridge's construction, called it "architecturally the finest bridge of them all."

But a year later, a catastrophe on the West Coast shook that image.

On Nov. 7, 1940, the deck of the Tacoma Narrows Bridge twisted itself apart and plunged into the water below during a fierce windstorm. No one was killed, but the collapse, captured on film, instantly became one of the most infamous engineering failures in history.

The prevailing theories in bridge design at the time paid little heed to aerodynamics, according to Henry Petroski, a professor of civil engineering and of history at Duke University who has written extensively on bridge design.

"The idea that a bridge roadway or a deck could undulate, could be moved vertically by the wind - that was just not thought to be something to worry about," he said. "The idea was to make the deck, the roadway of the bridge, as slender as possible. The aesthetic model was driving this, and it was generally thought that these bridges were so big, massive and heavy, built of steel and concrete, that the wind was just not going to move them. And that was wrong."

Even before the Bronx-Whitestone opened, engineers noticed that its deck would occasionally sway in the wind and shift back and forth, lengthwise, between the two steel towers.

The Bronx-Whitestone was neither as long nor as narrow as the Tacoma Narrows, but the same engineer, Leon S. Moisseiff, had worked on both bridges. The chief engineer of the New York bridge, Othmar H. Ammann, was on a commission that investigated the failure of the Washington bridge.

Mr. Ammann insisted that the Bronx-Whitestone was stable, but its pendulum-like movement alarmed drivers and pedestrians and Mr. Moses ordered it stiffened.

"He felt that the risk of losing motorists and therefore revenue far outweighed what the engineers said and that this perception of instability was unacceptable," said Darl Rastorfer, the author of "Six Bridges: The Legacy of Othmar H. Ammann" (Yale University Press, 2000).

In 1940, diagonal stiffening cables were installed on the bridge. In 1946, two steel trusses were erected on the sides of the bridge to stiffen it more. The trusses resulted in the elimination of the pedestrian walkways and the widening of the bridge from four to six lanes of traffic.

Bridge enthusiasts lamented that the installation of the trusses marred the bridge's aesthetic qualities. "It ruined the view of the skyline of Manhattan," Professor Petroski said.

As if those changes were not enough, engineers installed one more device - a counterbalance known as a mass damper - to the underside of the bridge in 1986 as yet another component for stability. Finally, an increase in traffic - from 6.3 million vehicles in 1940 to 45.2 million last year - has added stress, although the weight of the bridge itself is the greatest concern for engineers.

As a result of all this, the bridge has become too heavy and increasingly vulnerable to wear and tear. "Every time we added features, we were adding to the weight of the bridge," Mr. Ascher said.

To increase the bridge's longevity, engineers looked for ways to make the bridge lighter, while maintaining its ability to withstand wind. They also recruited help from engineers at two universities. In December 1998, Canadian scientists attached devices to the bridge to measure wind and vibration. Over two years, the data was transmitted to the University of Western Ontario.

Researchers there also built miniature models of the bridge made of "aluminum and some balsa wood and some plastic and some piano wire," according to J. Peter C. King, a civil engineer who directs the university's wind-tunnel laboratory.

The models were put in a 200-foot-long wind tunnel, which simulated average winds of 140 miles an hour and gusts of 210 miles an hour. The latter figure would represent winds stronger than a devastating hurricane.

Dr. King concluded that replacing the concrete deck with lightweight steel, removing the trusses and re-evaluating the need for the mass damper could yield more sophisticated ways of keeping the bridge stable.

"The thought at the time was more brute force - let's throw more stiffness at it and see what happens - rather than to try something more elegant or subtle," he said.

Meanwhile, at Lehigh University, in Bethlehem, Pa., researchers made a prototype of the proposed steel deck. Over nine months, they simulated the effects of a truck passing over the deck 239 million times. That amounts to about 175 years of traffic - about a century longer than the 75-year minimum life span for the new, post-diet bridge.

Last April, workers completed the replacement of the trusses with wind fairings - lightweight fiberglass structures that slice and deflect the wind as it buffets the bridge. The project, which cost $32 million, restored the bridge to its original appearance.

This spring, the replacement of the deck will start.

One lane will be closed to traffic at any time, but a temporary movable barrier will allow three lanes of traffic to move in the peak direction - toward the Bronx in the morning, toward Queens in the evening - during the commuter rush. The work is expected to last 101/2 months and cost $136.7 million.

Instead of the old asphalt coating, the new deck will have a surface of epoxy and sand to prevent skidding. For drivers, the only noticeable change will be the end of potholes.

At 61, Mr. Ascher is four years younger than the bridge. He described its re-engineering as one of the most intellectually challenging projects in his nearly 15 years at the bridge and tunnel agency.

"I think the bridge is in better shape than I am," Mr. Ascher said. "In many respects, I envy engineers coming into this business now for the first time. Technology has changed so dramatically that there are new, exciting, innovative ways to extend the lives, almost indefinitely, of these structures. I wish I was much younger and just coming in now, rather than being at the twilight of my career."