HISTORY, ENGINEERING AND CONSTRUCTION OF THE TAPPAN ZEE BRIDGE

The construction of the Tappan Zee Bridge began in 1952, and the bridge opened on December 15, 1955. At 3.1 miles, it was the longest bridge in New York State.

It carried Interstate-87/287 (the New York State Thruway) across the Hudson River at one of the its widest points, connecting South Nyack/Grand View in Rockland County and Tarrytown in Westchester County. The bridge contained the world's ninth-longest cantilever span (1,212 feet), clearing the river 149 feet above its mean low water mark, and was the first permanent bridge in the United States to be supported, in part, by buoyant caissons. Built at a time when high quality steel was in short supply because of the Korean War, the Tappan Zee Bridge had an expected service life of 50 years. However, the bridge remained in service until 2017 and was replaced by the new Governor Mario M. Cuomo Bridge.

Impact of the Bridge

From the day it opened, the Tappan Zee Bridge brought far-reaching changes on both sides of the Hudson. In Rockland, where more than 100 homes and businesses were torn down to make way for the span, population growth exploded—by 50 percent between 1955 and 1965, and 150 percent between 1955 and 1975. Of the 400 farms active before the bridge opened, all but 50 were sold to developers for conversion to housing to meet the growing demand. An expanding population brought in its wake a need for new streets, housing, schools, stores, places of worship, post offices, and more. New businesses moved in and created jobs for hundreds of thousands of people, which in turn spurred even more growth. The bridge created a gateway for residents to find new job opportunities in Westchester, something that would have been cost and time prohibitive before the bridge.

Over in Westchester County, the transportation connections created by the new bridge and the recently completed New York State Thruway generated substantial economic opportunities, even as once-quiet village streets filled with automobile traffic. In Tarrytown and its adjoining communities, the addition of the Tappan Zee Bridge to the transportation corridor attracted hundreds of millions of dollars in new residential development to house a booming population along with commercial and industrial construction facilities for companies such as General Motors, General Foods, and Kraft.

Engineering Challenges

When plans for a bridge between South Nyack and Tarrytown became public, one of the most frequently asked questions was: why build a bridge across the Hudson at one of its widest points for $80 million ($766 million in 2019 dollars) when there were many other less expensive choices? The answer lay at an intersection of politics and engineering. By law, any river crossing built within 25 miles of the Statue of Liberty fell under the jurisdiction of the Port Authority of New York and New Jersey. Therefore, in order for the revenue from the proposed Tappan Zee Bridge to belong exclusively to New York, it would need to cross the river north of that boundary. In fact, it would ultimately cross the river just beyond that boundary—far enough north to allow New York State to collect the toll revenue that would pay for the construction of the bridge.

It wasn't only the shore-to-shore width of the crossing that posed engineering challenges for designers, however. The new bridge would require a strong foundation; no small feat given the complexity of the riverbed topography, which consisted of layers of sand, silt, clay, and till above bedrock more than 1,000 feet below the surface in some locations. Where challenges arose, solutions were explored, including:

Causeways, Trestles, and Trusses

Starting on the western bank, the original bridge design called for a causeway to carry traffic from the shore across more than 1.5 miles of water to the bridge's central span. It was originally designed as a massive earthen "causeway," to support the roadway, similar to that visible in Piermont, NY, where an earthen causeway to a concrete pier exists to this day. After further investigation, this was seen as posing a significant navigational and environmental challenge, just one of the reasons the idea was dropped in favor of a series of short spans to carry the concrete road deck. The short spans were supported by thousands of long wooden pilings driven at short distances into the silt and clay of the riverbed - appearing like a hairbrush with many bristles extending into the riverbed.

Buoyant Caissons

The navigation channel had to be 1,200-feet wide and 40-feet deep, to accommodate river traffic in accordance with the 1951 USCG permit for construction. The length of that span meant there was a lot of weight resting on the foundations on either side. Bedrock was reachable at this part of the river, but buoyant caissons were a more efficient and economical solution. In the center of the Hudson, the bedrock is between 250 and 300 feet below the surface—too deep to reach with the drilling equipment that was available at the time. This was the reason efforts to build a river crossing in the 1930s was unsuccessful: the cost of the pilings required to stabilize the bridge was prohibitive. But a technique developed during World War II—the use of buoyant concrete caissons or boxes—provided the solution that made the Tappan Zee Bridge possible (and its engineering historic). The eight floating caissons each filled with a mixture of air, sand, and water supported the central section and were capable of bearing up to 80 percent of the structure's "dead load," i.e., the weight of the bridge itself and its permanent structural elements. Cofferdams filled with concrete provided additional support, and underdeck trusses resting on concrete columns made it possible to minimize the use of steel, which was in short supply during the time of the Korean War when the bridge was built.

Everyday Wear and Tear

According to a local newspaper account, the first two hours of the Tappan Zee Bridge's operation on December 15, 1955, saw 2,162 cars cross the span. After the novelty of opening day, daily bridge traffic totaled about 18,000 vehicles. However, growth was in full swing on both sides of the Hudson, made possible by—and in turn stimulating a dramatic increase in—automobile use. By 1960, daily traffic rose to 29,000 cars and by 1970, it had more than doubled to 66,000. Spurred by economic development—and opportunity—in both Rockland and Westchester counties and beyond, traffic continued growing, passing 112,000 vehicles per day in 1990, then 134,000 just 10 years later. By 2010, the number hit a staggering 144,000.

A bridge considered among the most modern in the nation in 1955 was now demonstrably ill-equipped to serve the amount of traffic making the daily trek over the Hudson. The bridge originally offered six lanes that were tight and narrow. In 1985, in an effort to relieve traffic congestion, the Thruway Authority converted the bridge's center median into a seventh lane. In 1992, the bridge introduced a movable barrier known as "the zipper" that allowed traffic in the center lane to be redirected during peak travel times. By now, an average of nearly 20,000 cars per hour crowded onto the bridge during peak-use periods.

While traffic was often at a standstill on the bridge, the need for repairs never ceased. The bridge had been in use for only five years before maintenance crews were busy on repairs and alterations. For example, the concrete deck needed resurfacing because winter salting was causing deterioration, while the bridge's open gutters had to be closed to prevent that salt from draining onto and damaging the steel supports. A steel guide rail was added to the central median for safety but was later removed to make way for a new lane. In 1970, maintenance crews had to replace the 250 wooden piles that made up the bridge's ice-breaker system. As the need for other significant maintenance work continued unabated, New York State's then-Governor George S. Pataki announced in 1999 that the Thruway Authority was considering plans to replace the Tappan Zee Bridge.

Next Challenge: Repair or Replace?

A thorough analysis of rehabilitation and replacement alternatives for the Tappan Zee Bridge continued over nearly a decade. Even before these had begun, inspections revealed some bridge components were nearing the end of their structural lives. The design and construction of the bridge did not permit widening or adding to the existing lanes, and the absence of breakdown lanes was a significant concern, in part because when an accident happened, traffic had to flow around it, which only added to the already serious congestion. By 2009, the bridge was found to fall short of 21st century code requirements for seismic and wind events. In the end, the evidence was unequivocal: replacement rather than repair would be more cost-effective, safer for drivers, and better for the environment. In 2011, a $3.9 billion design for a bridge to replace the Tappan Zee was selected, and construction began two years later. The new bridge, designed to last more than 100 years without major maintenance, would be named the Governor Mario M. Cuomo Bridge to honor the three-term, 52nd governor of New York.

Learner Outcomes

Students will be able to examine the many factors that influence engineering decisions including politics, geography, technology and cost. They will also be able to consider some of the factors in planning for a future bridge such as economic development, tourism and resiliency.

Materials

Building Big Buoyant Boxes for Bridge Substructure, Engineering News-Record (magazine), 7/9/1953*

Tappan Zee Bridge: A Foundation Triumph, Engineering News-Record (magazine), 4/14/1955*

After Long Controversy . . . Thruway's Long Bridge Goes to Work, Engineering News-Record (magazine), 12/15/1955*

Floating Concrete—A Revolutionary Feat, August 10, 2016
www.giatecscientific.com/education/floating-concrete-a-revolutionary-feat

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Original Tappan Zee Bridge
www.americanbridge.net/featured-projects/original-tappan-zee-bridge

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Tappan Zee Bridge Historic Overview
www.nycroads.com/crossings/tappan-zee

Activity

1. What were some of the options engineers considered when designing the Tappan Zee Bridge? How did location, technology, and environmental considerations influence their decisions? Relate the challenges in the 1950s to what the challenges may be today and develop a proposed plan to solve any identified challenges and how those challenges may impact future activity on or near the new bridge.

2. Dramatic increases in automobile use placed the Tappan Zee Bridge under considerable stress that original designers did not anticipate. What steps can its replacement, the Governor Mario M. Cuomo Bridge, take to address increasing automobile usage? Can it continue to welcome more traffic for the next 100 years? Create a future projection of daily vehicle volumes for 2120 and brainstorm solutions, including alternatives to automobile travel, to accommodate those volumes.

3. How did the use of buoyant caissons make the Tappan Zee Bridge possible? How is that approach being used today, and why?