GOVERNOR MARIO M. CUOMO BRIDGE

COWI

CONTENT

1 PROJECT INFORMATION

PROJECT NAME
Governor Mario M. Cuomo Bridge

LOCATION
N 41°04'16.4' W73°53'43.9, South Nyack to Tarrytown, New York, USA

YEAR COMPLETED
2019

CATEGORY
B. Transportation

ENTERING FIRM
COWI North America Ltd.

ROLE OF ENTERING FIRM
Cable-stayed main span design and erection engineering.
Ship impact assessment for the entire bridge.
Probabilistic 100-year service life design for the entire bridge.
Preparation of the operations and maintenance manual for the entire bridge.

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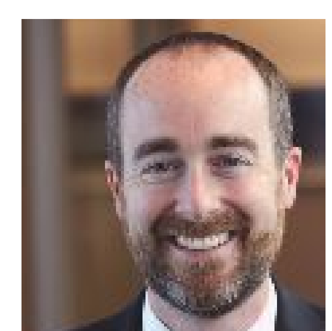


CHRISTOPHER SCOLLARD, P.ENG

Governor Mario M. Cuomo Bridge
COWI Project Manager

2 PROJECT HIGHLIGHTS

INNOVATION

The existing Tappan Zee Bridge was in rough shape. Crumbling concrete, deterioration of the timber pile foundations and high traffic volumes plagued this important Hudson River crossing north of New York City. During a speech at the bridge site in 2014, American President Barack Obama remarked, “At times, you can see the river through the cracks in the pavement. Now, I’m not an engineer, but I figure that’s not good.”

The replacement Governor Mario M. Cuomo Bridge, comprises dual cable-stayed main spans and associated approach structures that became one of the largest ever design-build transportation projects in the United States and, at 5km long, is the largest bridge construction project in New York State history. North Vancouver engineers, COWI, as subconsultant to HDR, were key to the project as the main span designer and erection engineer, and as the service life engineer for the entire bridge, ensuring it serves the public for its 100-year minimum design life. Construction began in 2013 and the structure opened fully to traffic in September 2018.

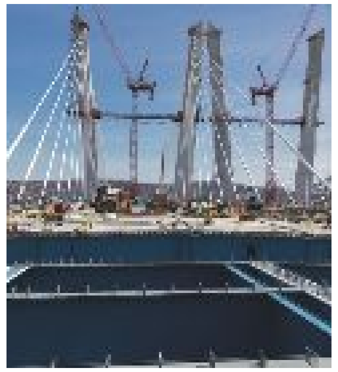
The main span bridges carry eight traffic lanes and comprises 366 m navigation spans and 157m side spans. Iconic V-shaped concrete towers rise 125m above the Hudson River and are supported on concrete-filled steel pipe pile foundations.

COWI completed the durability design using a full probabilistic approach- a first for a major North American bridge. This involved using reliability methods to identify the concrete permeability and cover thickness necessary to achieve a 100-year service life before major maintenance for non-replaceable bridge components – this is 33% longer than for typical bridges.

The bridges are designed for the potential future installation of a cable-stayed commuter rail bridge between the adjacent eastbound and westbound bridges. The inclined tower legs are oriented so that connecting members between the independent towers can be added to create an efficient A-frame support system for the rail bridge deck. The foundations are designed to support a future rail bridge without strengthening, reducing the potential environmental impact on the Hudson River.

Given the bridge is classified as critical infrastructure, the Owner required incorporation of structural redundancy and hardening to mitigate the effects of an accidental or intentional event that could compromise the structural integrity. As an industry first for cable-stayed bridges, COWI’s design contains advanced features that will allow the bridge to sustain localized damage/failure without it leading to progressive collapse.

The iconic V-shaped towers, complete with architectural chamfered tops, will provide efficient A-frame action to support the future installation of a cable-stayed commuter rail bridge between the twin structures.



COMPLEXITY

Aerodynamic behaviour and difficult foundation conditions were two significant complexities for the main span design.

The construction of two independent cable-stayed bridge decks only 30 m apart is unprecedented and required novel wind engineering work to confirm acceptable aerodynamic behavior. To accurately assess the complex aerodynamic interaction of the two decks, a suspension rig wind tunnel test system that allowed both bridge decks to move independently was developed and built by wind engineering consultant RWDI. A combination of numerical methods and extensive experimental procedures allowed COWI and RWDI, to collaboratively improve the aerodynamic behavior of the bridges. The first use of open steel barriers on a long span cable-stayed bridge in North America eliminated the need for leading edge treatments, usually needed to achieve the required aerodynamic behavior. Sectional model tests and wind induced buffeting analysis was confirmed by designing and testing a full 3D aeroelastic model of the bridge in the wind tunnel.

An additional project complexity was the difficult geotechnical conditions at the bridge site. The elevation of the bedrock at the site varies considerably and is more than 200 m below the surface in some locations along the bridge length. To overcome the challenging geotechnical conditions for the design of the large tower pile caps, which are longer than a football field, a static and dynamic pile testing program was implemented. This test program provided assurance that the foundation piles could achieve the capacity required to support the twin cable-stayed bridges and potential future commuter rail bridge.

SOCIAL AND/OR ECONOMIC BENEFITS

Community-driven design and aesthetic features were an important success factor. The Owner held more than 1,000 meetings with residents, community groups and other stakeholders. The Owner established a Visual Quality Panel (VQP), comprising design professionals and community leaders, to collaborate with the project team. COWI incorporated several VQP recommendations in the final bridge design, including architecturally-chamfered tower tops and a shared use bicycle/pedestrian path with scenic Hudson River overlooks.

Another important project benefit is a safer Hudson River crossing. The accident rate on the existing bridge was twice the rate on the rest of the 900 km long Thruway. The new bridge provides wider traffic lanes, wide shoulders for emergency services and disabled vehicles, and a gentle 1.5% grade compared to 3% on the existing bridge, which negatively affected larger trucks creating undesirable speed differentials.

The financial benefit of the project is tangible: the design-build contract price for the bridge was approximately equal to the anticipated 20-year maintenance cost of the existing bridge and the innovations implemented by the design team resulted in a contract price that was close to $1B lower than two competing proposals.

The economic benefits of the project extend beyond the savings to the Owner. The Owner estimates that more than 800 New York businesses were awarded contracts to provide goods and services for the bridge construction. 10 percent of all subcontracts, by price, were awarded to Disadvantaged Business Enterprises (DBEs), defined as small businesses that are owned and controlled by socially and economically disadvantaged individuals.

The sun sets over the picturesque Hudson River Valley, illuminating a landmark replacement structure that will provide New York State with environmental, social and economic benefits for years to come.

ENVIRONMENTAL BENEFITS

The capture of environmental benefits was prioritized throughout the project. COWI directly contributed to this by working with the contractor to design an economical bridge that could be constructed efficiently – minimizing the consumption of unnecessary resources and materials. The bridge also incorporates community requested components, mitigates negative environmental impacts and promotes the conservation of local peregrine falcons and fish habitat. These accomplishments demonstrate the Engineer’s expanding role in society and the need for the Engineer to consider the triple bottom line in all designs.

COWI’s service life design provides the project with significant environmental benefit. Completing detailed, probabilistic calculations to ensure the non-replaceable bridge components can reach their 100-year design life limits the environmental consequences of a potential premature bridge replacement. The marginal increase in initial cost of the structure to incorporate the durability-enhancing design aspects, such as galvanized steel reinforcement and less permeable concrete, results in a structure with a lower life-cycle environmental footprint.

The picturesque Lower Hudson Valley is home to a diverse natural environment and is an important habitat for peregrine falcons, which were part of the United States endangered species list until 1999. Peregrine falcons had been nesting on the existing Tappan Zee Bridge for several years and so a new nesting box was incorporated into one of the cable-stayed bridge towers to provide a new home for this important species. In 2018, a male falcon discovered the new nesting box and just this month four eggs have been sighted in the new home.

MEETING CLIENT'S NEEDS

Constructed in 1955, the Tappan Zee Bridge was functionally obsolete and in poor condition. Rehabilitation costs were estimated at $3 to $4 billion over the next 20 years, with $750 million already spent over the past 10 years. The Owner's needs and how they were met by the design are described in the table below:

NEED	SOLUTION
User safety.	Designed in accordance with current codes and standards for all relevant loading, including traffic loading, earthquakes, extreme winds, vessel collisions and river bottom scour.
Reduced life-cycle operations costs.	Probabilistic service life design for 100-years before major maintenance for non-replaceable components. Preparation of an extensive operation, maintenance, access and inspection manual to guide future bridge management activities. Incorporation of fixed and movable access equipment to facilitate inspection and maintenance.
Operational redundancy to mitigate the effects disruptive incidents on bridge users.	Provision of wide shoulders (westbound 6m and 3m / eastbound 7.6m and 3m) to allow for emergency vehicle access or detouring traffic around an incident. Incorporation of advanced design features that allow the bridge to sustain localized damage/failure without it leading to progressive collapse
Support future commuter rail transit.	Foundations designed and constructed to support a potential future rail bridge between the two traffic bridges without any future marine construction.
Not disturb the diverse wildlife in the Lower Hudson Valley.	Peregrine falcon nesting box incorporated into the one of the tower tops. Steel pipe piles installed with the use of noise mitigating measures such as bubble curtains.

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