Local News

Champlain Bridge repairs demand inventive solutions

The art and craft of keeping the decrepit span in one piece.

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Published Oct 28, 2014 • 4 minute read

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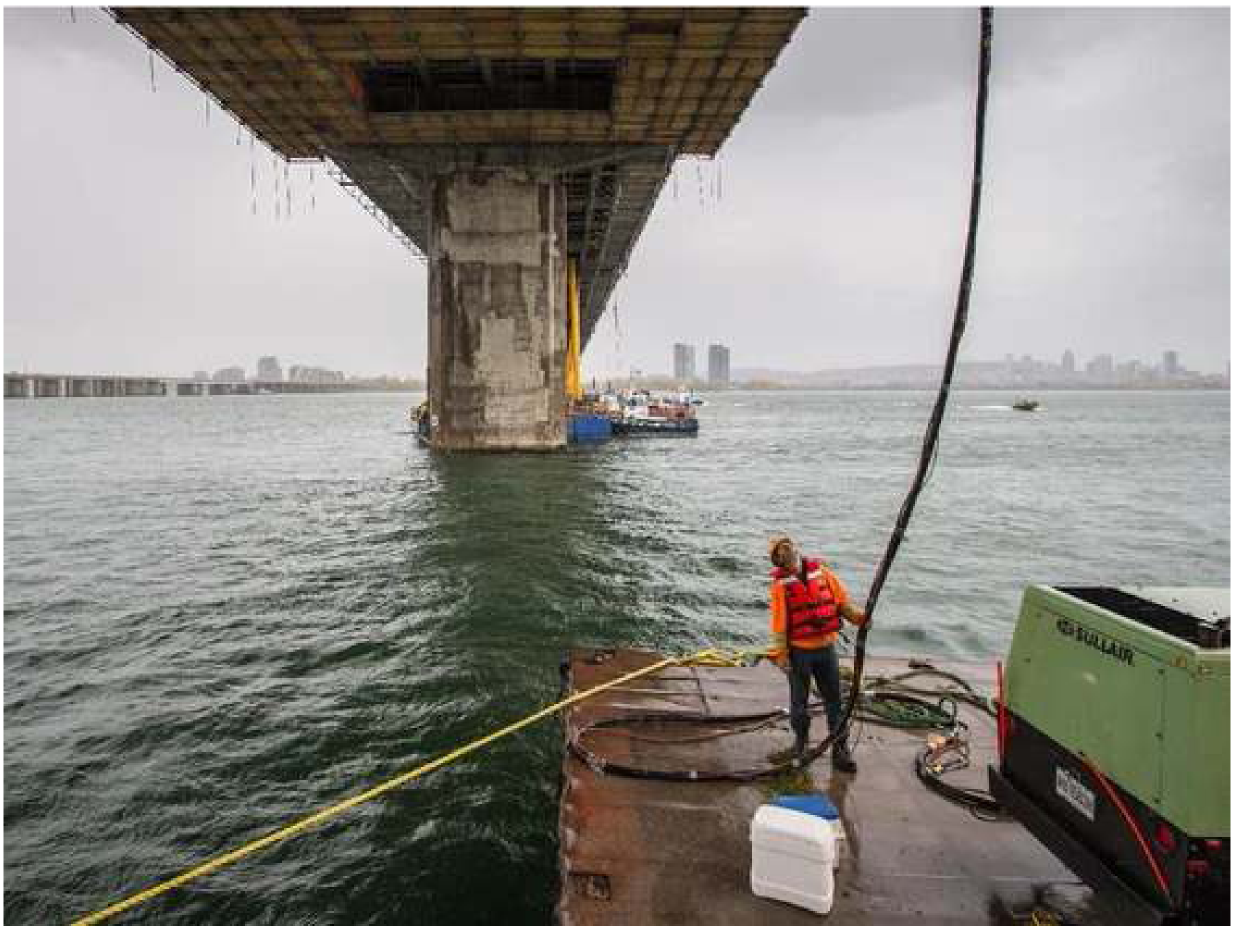

A construction worker stands on a floating service platform under the Champlain Bridge on Wednesday, Oct. 15, 2014. PHOTO BY DARIO AYALA /Montreal Gazette

Call it a $500-million bandage.

With a new bridge still at least four years away, and the current Champlain Bridge in a state of advanced deterioration, engineers and work crews have had to come up with innovative methods to keep all lanes open on Canada's busiest bridge.

Keeping it all together is the task of Steve Tselios, the senior director of engineering for The Jacques Cartier and Champlain Bridges Incorporated (which also includes half of the Mercier Bridge).

Most of the deterioration currently plaguing the bridge dates back to the first 30 years of its life, before proper drainage was installed in 1995. Until that point, a corrosive mixture of water and salt during the wintertime would drip over the concrete beams holding up the bridge.

“If it had proper drainage, we would have been in much better shape,” Tselios said. “That triggered everything; and because it’s concrete, it took many years to see the signs of what’s happening.”

The bridge is made up of 50 identical spans. Each span has seven beams running in the direction of the lanes of traffic. Because of the drainage problems, the beams on each of the bridge’s extremities — 100 in all — are the ones that are the most problematic.

Termed an innovative design in 1962, the bridge’s unique structure poses the greatest challenge for its rehabilitation. Because the bridge was built with all the beams interconnected, it’s impossible to remove one and replace it with a new one, as is the case with most other bridges.

So engineers had to come up with systems to reinforce the bridge that have never been tried before.

“This is all new conceptual design,” Tselios said. “We didn’t go into a textbook or look at another bridge in the world to find this out. These are individual, very specific problems for this type of bridge.”

Each beam is made up of 24 steel cables that give the beams their rigidity, but the salt and water infiltration has corroded many of those original cables. Engineers evaluate the strength of each span by taking out a small section of the concrete. They then figure out how many of the cables they believe have corroded, and add capacity, in some cases the equivalent of double the number of cables that have failed. That involves plugging numbers into a formula that has already been determined by a team of engineers.

Because they can’t replace the corroded cables or the problematic beams, engineers have come up with innovative ways of reinforcing the structure from the outside.

Most of the 100 problematic beams are being reinforced in three ways:

• Concrete anchors are added at the ends of each beam, and are connected by horizontal posts that are tightened, which engineers call external post-tensioning. Those posts stop vertical cracks from forming in the beams.

• About 40 of the beams are now reinforced with what are called queen posts, a new innovation designed specifically for the Champlain. The queen posts run diagonally down the side of the spans, meeting in the middle and are then brought under tension. Their purpose is to prevent diagonal (or shear) cracks from forming in the extremities of the beams.

• The beams are also held together with carbon fibre, a super strong material in the form of a mesh that is wrapped around the beams to prevent cracks from forming, or to keep the beams together if there is a new crack.

“It’s like when you have a piece of paper that’s ready to rip, and you put on duct tape,” Tselios said. “Carbon fibre is a mesh on the outside, but we know that it acts stronger than rebar.”

Tselios said even with all these reinforcing measures, engineers are still limited as to how much they can strengthen the bridge.

During a routine check last November, a one-millimetre vertical crack was found in one of the beams, stretching from the top of the beam to the bottom. While a hairline opening may not seem like a big deal, Tselios explained it showed the structure of the beam was compromised.

“We continued to examine it, and saw it was going higher and wider. For a beam 120 metres long, to have a crack like that, it’s important.”

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Tselios said he saw the horizontal poles start to “work very hard,” with concrete anchors looking like they would be pulled out of the beams. That’s when crews shut down traffic on two lanes of the bridge. A “super beam” made of steel was installed as a temporary measure to hold up the failing beam.

Lanes of traffic had to be closed for the super beam, until it could be replaced in the spring with a modular truss, the ultimate solution, since it acts as a new steel beam, and holds up the entire weight of the concrete beam.

The super beam solution was an emergency measure that was prepared years in advance. So was the modular truss. But going forward, there will be more modular trusses installed on the bridge, since queen posts can only increase the bridge’s capacity by about 20 per cent.

Teams are expecting to add 13 more trusses to the bridge’s most problematic beams by the end of the year, and another 14 trusses next year. By 2018, Tselios predicts about half the 100 problematic beams will be held up with trusses, depending on the results of future annual inspections.

There are still three super beams standing ready in an emergency if another crack is detected, several trusses are also on standby.

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