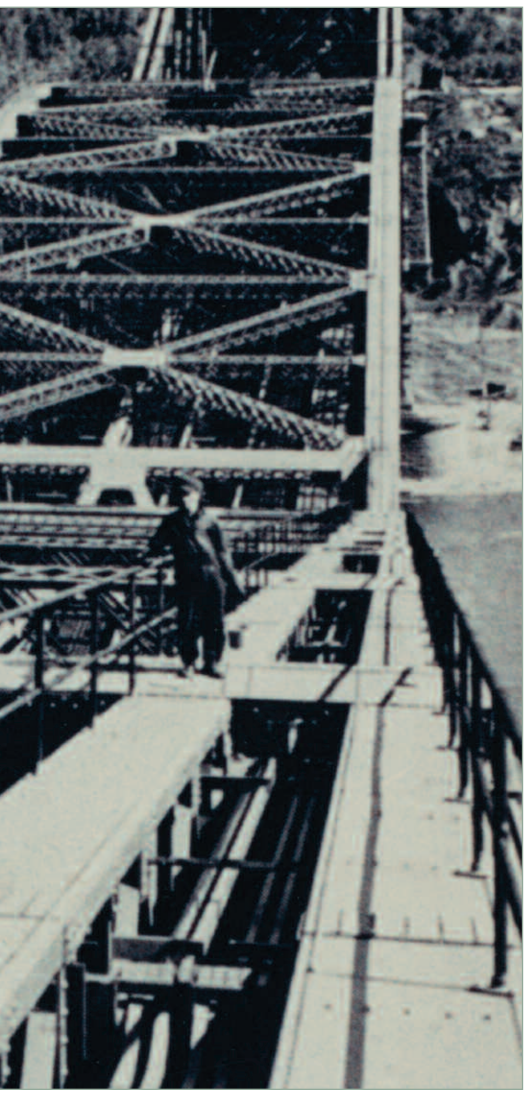
AFTER THE FALL
What the Quebec Bridge means today

By Michael Mastromatteo

Does a 100-year-old disaster still have relevance for the engineering profession? The technical and design errors contributing to the Quebec Bridge collapse of 1907 have been fully annunciated, but its lasting significance to a profession dedicated to public protection is still open to debate.

The cantilevered Quebec Bridge over the St. Lawrence River, just west of the provincial capital is regarded in engineering history books as a triumph over failure and adversity.

The same expanse is also laden with symbolism for engineers, not only as a monument to accomplishment and perseverance, but also as a steely reminder of the devastating consequences of engineering gone awry. To this day, the myth persists



that engineers' iron rings are made from the twisted wreckage of the Quebec Bridge.

Like a fable or morality play, there is moving symbolism still to be drawn from the ill-fated bridge. August 29, 2007 marked the 100th anniversary of the infamous Quebec Bridge collapse, which claimed the lives of 75 workers, and which gave pause to a profession swollen with confidence and hubris as the result of previous engineered glories.

The bridge's tortured construction history took a second fateful hit in 1916. This time, guide wires lifting the centre span into place gave way, resulting in the span's 150-foot plunge into the river below. The second failure came at a cost of 13 human lives and, while this could not as readily be ascribed to an engineer's carelessness or poor judgment, it forever added to the dubious lore of the Quebec Bridge.

Much has been made of the errors and reckless assumptions on the parts of Theodore Cooper, a consulting engineer on the Phoenix Bridge Company design team, the rest of the design team, and the Quebec Bridge & Railway Company owners, in analyzing the disaster. A subsequent Royal Commission, which included future University of Toronto Engineering Dean John Galbraith, succinctly cited errors in judgment on the part of Cooper and his lead design engineer, Edward Szlapka.

Other than damage to the reputation of the renowned, highly accomplished and soon-to-retire Theodore Cooper–and an assortment of lawsuits paid to the families of the victims–the Quebec Bridge disaster exacted only scant retribution. Still, the experience became instructive in the push for greater standards and public accountability for a young but exuberant engineering profession, eager to take on the greater technical and building challenges of the 20th century.

Cooper's decision part way through construction to extend the length, and thus the dead weight of the bridge's centre span, would ultimately prove fateful. Although these revisions were beyond the designer's original calculations, the parties involved assumed that the additional weight and stress factors would fall within known tolerances. Complicating this guesswork, were pressures to complete the project on time and within significant financial constraints. Cooper agreed to act as consulting engineer for a modest fee, which ultimately served as a disincentive for the engineer to expend additional resources in double checking the bridge design revisions.

It was evident that Cooper recognized the weight of the extended centre span was some 3.7 million kilograms greater than original estimates. Rather than taking on the costly and time-consuming effort of recalculation, and owing to the fact that construction had already begun, Cooper was faced with the unenviable situation of condemning the original design and starting over, or trusting that the additional weight wouldn't pose a problem. Engineering historians speculate that Cooper might also have been motivated to stay with the project to cement his already lofty reputation as builder of one of the greatest bridges in the world.

Although site engineers and construction foremen noticed bending and distortion of steel support beams as construction progressed, none accepted responsibility to order a halt to proceedings. Cooper himself called to suspend work on the bridge when the bending matter was brought to his attention days before the collapse. But the lack of a clear command structure, coupled with communication delays, resulted in the order going unheeded.

In any case, the federal government's Royal Commission on the disaster noted in February 1908: "A grave error was made in assuming the dead load for the calculations at too low a value and not afterwards revising this assumption. This error was of significant magnitude to have required condemnation of the bridge, even if the details of the lower chords had been of sufficient strength, because, if the bridge had been completed as designed, the actual stresses would have been considerably greater than those permitted by the specifications. This erroneous assumption was made by Mr. Szlapka and accepted by Mr. Cooper, and tended to hasten the disaster."

The Royal Commission report authors did not limit all blame to Cooper and Szlapka, however. They suggested that the significant loss of life resulting from the collapse might have been prevented had principals with the owner and contractor companies exercised better judgment and not deferred entirely to Cooper's name and reputation.

In the 2001 work, *The Bridge at Quebec*, author William Middleton cites “unprecedented design stresses” as a key to the disaster. For Middleton, however, Cooper’s decision to go it alone as consulting engineer was equally instructive. “The best of engineers can make mistakes or suffer lapses in judgment,” Middleton said, “and good engineering practice is founded upon careful independent checking and review by knowledgeable peers. This was notably absent in the design of the Quebec Bridge, and it had much to do with Theodore Cooper, who seems to have been self-confident to the point of arrogance.”

Roger Dorton, P.Eng., former chief bridge engineer with the Ontario Ministry of Transportation, is one of Canada’s foremost civil engineers. The recipient of an Ontario Professional Engineers Award (1980), Dorton has had a long interest in the significance of the Quebec Bridge disaster to the engineering profession.

Dorton hesitates to put too much of the blame on Theodore Cooper for the collapse. “Certainly the higher final dead weight was a contributing factor, but I would not call it the fatal flaw,” Dorton told *Engineering Dimensions*. “I do not think there was one only. Like most failures, it is probably the result of a combination of faults.”

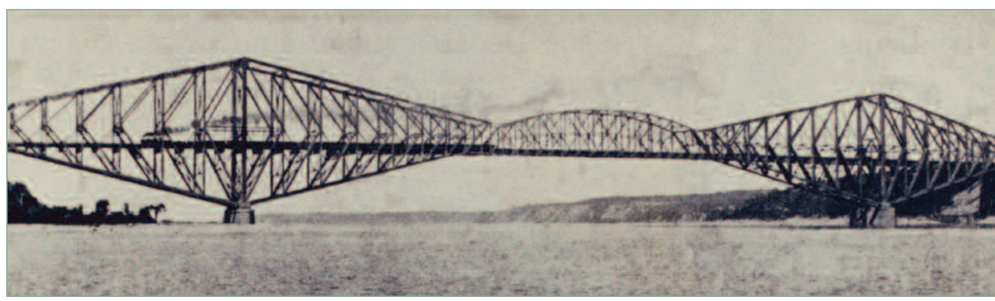
Dorton suggested that safety on the overall project was compromised by economic, administrative and related factors. “Cooper’s final responsibilities were well beyond what could adequately be covered by his fees, and he was not able to hire top assistants for financial reasons. This situation still has relevance,” he said. “I think as well that there is a degree of blame associated with all participants. Inadequate funding is one of the lessons, but poor organization, unclear responsibilities, poor communication, too much reliance on one person, as well as inadequate design, are all issues that should be remembered today.”

Amid the recriminations and assignation of blame in the wake of the collapse, a redesigned cantilever bridge was finally completed in September 1917. At the time of completion, the influential *Engineering News-Record* heralded the bridge’s technical accomplishments, including its use of the new “K system” of web bracing, and its advancement of the bridge building fraternity’s knowledge of large compression members, tension bars and steel truss distortion.

“The great value of achievement lies in the inspiration emanating from the courage of the men who have erected on the failure of 1907 and the loss of 1916 this greatest of bridges,” the magazine reported, “and in doing so not only have erected a monument to themselves and their courage and ability, but have vindicated the profession before a doubting world.”

Perhaps a part of that vindication stemmed from the profession’s ability to learn from failure. Although there is no direct linkage between the Quebec Bridge disaster and the push for improved regulation, practice standards and accountability of professional engineers, there is little doubt that the incident provided lasting lessons for engineering as a whole.

As US civil engineer Henry Petroski noted in his 1995 work, *Engineers of Dreams, Great Bridge Builders and the Spanning of America*, the Quebec Bridge disaster might have been avoided had a courageous whistle-blower been on hand. “In its discussions of the various bridge-building organizations involved and their respective faults, the [Quebec Bridge] inquiry commission was clear regarding the sense of hubris and overconfidence that success can bring to an organization. In this regard, the Royal Commission anticipated in some ways by eight decades what the Presidential Commission would find in its investigation of the [1986] space shuttle Challenger accident. Although there do not seem to have been too few assistants in that more recent accident, there certainly seem to have been too many overconfident bosses, or at least too many bosses willing to make compromises for other than purely technical ends.”



The Quebec Bridge experience of 100 years ago represents a milestone event in furthering the public protection ideals of Canadian engineering.

The Quebec Bridge experience of 100 years ago represents a milestone event in furthering the public protection ideals of Canadian engineering. Although the disaster predated the formation of regulatory organizations and engineering legislation in Canada by at least 15 years, it undoubtedly fostered a recommitment on the part of practitioners to take a more expansive view of the multitude of constraints involved in engineering projects. Ironically, it’s a lesson that applies today in light of dramatic bridge failures in Laval, Quebec, in 2006, and this summer’s tragedy in Minneapolis. While these recent collapses appear related to maintenance rather than design problems, they provide a sobering reminder that technological progress always involves some risk, and that engineers have a special responsibility to identify, account for, and minimize its impact.