## Historic Structures

significant structures of the past

## Quebec Bridge

## Part 2

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total of 75 men were killed instantly, with 11 escaping with their lives, in the bridge collapse on August 29, 1907. How could this have happened? Weren't Cooper and the Phoenix Bridge Company acknowledged to be leaders in the bridge building business? *The Engineering News* wrote:

"It is with keenest regret that we record the collapse on Aug. 29 of the great cantilever bridge under construction over the St. Lawrence River at Quebec. We are sure this regret is shared by every engineer who takes the least pride in his profession and its achievements. And the feeling is even deeper than regret. When the newspapers of last Friday morning spread the news of the terrible disaster at Quebec to every corner of the country, thousands of engineers, as they read the story, were grieved

and sick at heart. They felt not only horror at the fearful loss of life, sorrow and sympathy for their brothers whose professional and business reputation were dealt

a cruel blow when the huge steel structure fell into the St. Lawrence, but also a sense of personal loss as well.

It could not be otherwise. Public confidence in engineers and engineering constructors and in the safety and reliability of their works is an asset of the whole engineering profession. To have this public confidence receive such a blow as this at Quebec is a loss almost incalculable. For decades to come, the Quebec disaster will be quoted, in public and in private, as an unanswerable proof of the unreliability of engineers and their work – of even the best engineers."

The Engineering Record wrote of the collapse, "Engineers themselves know full well that probably no structure ever received more careful attention in design, manufacture and erection than the Quebec Bridge and they will be unwilling to attribute its collapse to defective proportions, inferior material or faulty erection until definite proof is established to the contrary."

Several investigations were held, with the major one, the Royal Commission staffed by Canadian engineers, appointed on August 30, the day after the failure. The chairman of the team was Henry Holgate, assisted by two civil engineering professors, John Galbraith from the University of Toronto and J. G. G. Kerry from McGill University. The team visited the site immediately after the collapse, and took testimony in Quebec between September 9 and 24 and in Ottawa on September 26 and 27. They went to New York City to interview Theodore Cooper for a week and then went to Phoenixville to interview the Phoenix Bridge Company personnel. The team members also revisited Cooper and the Phoenix Bridge people later on in December.

The Commission also talked with Charles Macdonald, Henry Hodge, Ralph Modjeski, F. C. Kunz and John V. W. Reynders of the Pennsylvania Steel Company that was building the Blackwell's Island Bridge across the East River in New York City. In addition, they spoke with some of the leading professors of the day, Mansfield Merriman, W. C. Kernot, William H. Burr, Edgar Marburg, H. M. McKay, and G. F. Swain.

In addition, the Board hired C. C. Schneider (STRUCTURE, January 2011) to advise them on structural design of the bridge. Schneider had seven conclusions, the most important ones being:

2. The trusses, as shown in the design submitted to this writer, do not conform to the requirements of the approved specifications, and are inadequate to carry the traffic or loads specified.

3. The latticing of many of the compression members is not in proportion to the section of the members which they connect.

6. The present design is not well adapted to a structure of the magnitude of the Quebec Bridge and should, therefore, be discarded and a different design adopted for the new bridge, retaining only the length of the spans in order to use the present piers.

Cooper's testimony, as well as that of the Phoenix Bridge personnel, was extensive and published in the journals of the day. Cooper stated, "I had and have implicit confidence in the honesty and ability of Peter Szlapka, the designing engineer of the Phoenix Bridge Co., and when I was unable to give matters the careful study that it was my duty to give them, I accepted the work to some extent upon my faith in Mr. Szlapka's ability and probity." Another question and answer was,

Q. Do you consider that the engineering data at our disposal are sufficient to enable engineers to design members similar to those in the lower chord with safety and economy? Would you now recommend any material changes in the detailing of these or any other members, and, if so, what would these changes be?

A. My responsibilities, gentlemen, end as soon as I have served my duty of aiding you in reaching the truth in regard to the destruction of this bridge. While I have my views and such views are at the service of those who have heretofore relied on me, I shall decline to take any executive or responsible position in connection with the corrections of the errors that we now recognize in this work; it must be referred to younger and abler men.

With all the testimony, the report of Schneider, and inputs of the leading cantilever bridge



designers and builders, the Commission released its report in March 1908. The report had fifteen findings. The most important were as follows:

e. The failure cannot be attributed directly to any cause other than errors in judgment on the part of these two engineers. [Cooper and Szlapka]

f. These errors of judgment cannot be attributed either to lack of common professional knowledge, to neglect of duty, or to a desire to economize. The ability of the two engineers was tried in one of the most difficult professional problems of the day and proved to be insufficient for the task. g. We do not consider that the specifications for the work were satisfactory or sufficient, the unit-stresses in particular being higher than any established by past practice. The specifications were accepted without protest by all interested.

h. A grave error was made in assuming the dead load for the calculation at too low a value and not afterward revising this assumption. This error was of sufficient magnitude to have required the 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. The erroneous assumption was made by Mr. Szlapka and accepted by Mr. Cooper and tended to hasten the disaster.

n. The professional knowledge of the present day concerning the action of steel columns under load is not sufficient to enable engineers to economically design such structures as the Quebec bridge. A bridge of the adopted span that will unquestionably be safe can be built, but in the present state of professional knowledge a considerably larger amount of material would have to be used than might be required if our knowledge were more exact.

o. The professional record of Mr. Cooper was such that his selection for the authoritative position that he occupied was warranted and the complete confidence that was placed in his judgment by the officials of the Dominion Government, the Quebec Bridge & Railway Company and the Phoenix Bridge Company was deserved.

The Engineering Record wrote of the Report, "It is seldom that the responsible engineer for any work great or small has more authoritatively or more effectively impressed his engineering judgment upon



Peter Szlapka.

the work in his charge than in this case ... Perhaps the most painful part of the evidence is that in which the Consulting Engineer makes the plea of impaired health for not exacting from both the contractor and the Quebec Bridge Co. certain requirements of design and plans in the one case, and the necessary organization for the proper performance of the work on the other. Unfortunately such pleas are admissions of official shortcoming, however much a man may feel the disability of ill health, they give him no relief from official responsibility. There is one only clear way by which he can divest himself of the responsibilities of official position and that is by a formal withdrawal from it... The Consulting Engineer makes a further point in his evidence that the fee he received was quite insufficient to enable him to maintain a proper office work force for the discharge of the duties imposed upon him in his official capacity... When he accepted the fee he accepted all of the responsibilities of the position. No engineer has any right whatever to consider his responsibilities lessened because his fee is not as large as it should be... The failure of the Quebec bridge reflects in no way whatever upon the American engineering profession, it simply shows that the exactions of responsibility unfortunately make no compromise with the disabilities of age and ill health, even when combined with a meager compensation."

The work was then turned over to the Transcontinental Railway Commission. To ensure that there would not be any mistakes, they appointed an International Panel of bridge experts. H. E. Vautelet was appointed Chairman and Chief Engineer with Maurice Fitzmaurice, then chief engineer of the London County Council, and Ralph Modjeski (STRUCTURE, January 2013) from the United States.

The Panel went to Phoenixville to talk with Szlapka and J. Sterling Deans, the Reeves Brothers and others. After a great deal of study, they fully endorsed the Holgate Report, as well as that of C. C. Schneider. No part of the existing bridge would be usable in any new structure and they were to start over with an entirely new structure! The Board was initially in favor of a cantilever bridge, but they also looked at several suspension bridge designs before deciding on a cantilever.

Many questions were asked about the kind of truss to be used. Should they be vertical and parallel, or inclined as on the Forth Bridge? Should they have straight or polygonal chords? What kind of a web system should be used, single or double intersection or some entirely new system? The Board, with the full financial backing of the government, consulted freely with other engineers and bridge building companies to help them make their decision.

The Panel prepared its own design, largely that of Vautelet, which had parallel trusses, straight chords and an unusual web pattern. Modjeski and Fitzmaurice were still carrying on their own engineering careers and had reservations about the design, while Vautelet devoted full time to the project. The Panel, however, passed the following resolution of May 2, 1910:

"It is resolved that the plans and specifications for a cantilever design, now completed, be approved and submitted to the Minister for tenders, and that, in the event of a better design being submitted by any of the bidders, shall be adopted."

Prior to this official resolution, the Board had notified several bridge companies in late 1909 that they would be requesting tenders, and that they could view the Board's design early in 1910.

Fitzmaurice resigned his position in June 1910 to return full time to his position in London. He was succeeded by Charles Macdonald (STRUCTURE, January 2009), who agreed to serve only as long as necessary to evaluate the tenders. In the same month, the Department of Railways and Canals officially requested tenders on their "superstructure design comprising 80 sheets of drawings, 6 or 8 feet long, and contract bids on them and on alternate plans which may be prepared by the contractors in accordance with the printed specifications." In other words, the Panel had a design, which, even if they had some reservations about it, would work. If any tender could improve on it so much the better.

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A few of the tenders submitted, along with final design 1910.

After reviewing the tenders, Vautelet, Macdonald and Modjeski reported to the Minister of Railways and Canals that "design V of the Board and the scheme of erection proposed by any one of the bridge companies would result in a satisfactory structure." They also recommended designs A, B, C of the St. Lawrence Bridge Company. The Minister, however, wanted a specific recommendation, from the Board. The Panel, however, could not agree on a specific recommendation as Vautelet recommended one of the tenders on his own design and Macdonald and Modjeski recommended design B of the St. Lawrence Bridge Company. The minister would not accept a split recommendation, so he appointed two more engineers to the Panel to help in making the decision. They were M. J. Butler, a Canadian, and Henry Hodge, an American. After an extensive review of the tenders, they agreed with Macdonald and

Modjeski that the plan B submitted by the St. Lawrence Bridge Company was the best tender. Their reasons were as follows:

a. The type of design offers greater safety to life and property during erection, as well as economy and rapidity of construction. b. The design contains the minimum of secondary members and requires few, if any, temporary members during erection. c. The system of triangulation, by dividing the web stresses, reduces the members to more practical sections and simplifies the details of construction.

d. The general appearance of the structure is, in our opinion, improved.

Vautelet resigned on February 22 while deliberations were ongoing and Macdonald took over as acting Chairman. The Minister, upon considering the high cost of building highway approaches to the bridge, decided to omit the two roadways and accepted plan B of the St. Lawrence Bridge Company.

A contract was signed with the St. Lawrence Bridge Company, a joint venture of the Dominion Bridge Company and the Canadian Bridge Company, on April 4, 1911. With the signing of the contract, Macdonald resigned as acting chairman and was replaced by Lt. Col. Charles N. Monsarrat who was engineer of bridges for the Canadian Pacific Railway. On May 17, 1911, C. C. Schneider was appointed a full member of the Board, which then consisted of Monsarrat, Modjeski and Schneider. Erection of the approach spans on the North end of the bridge was completed by November 7, 1913. Work on the bridge proper began on May 21, 1914, when the traveler moved out onto the falsework for the anchor arm. Everyone associated with the bridge believed that with all the precautions taken and checking done, nothing could possibly go wrong during construction, and the bridge would open in 1916.