

deavor to make a personal examination of the suspected chords.

"Shortly after 11 a.m. on August 29th, Mr. Cooper reached his office (in New York) and found Mr. McLure there. After a brief discussion Mr. Cooper wired to Phoenixville as follows: 'Add no more load to bridge till after due condition of facts. McLure will be out at 5 o'clock.' This message was received at Phoenixville at 1.15 p.m. Mr. Cooper was then under the impression that work had been stopped on the bridge.

"Mr. McLure had promised to wire Mr. Cooper's decision to Mr. Kinloch immediately, but did not do so. Mr. Deans received Mr. Cooper's telegram at 3 o'clock p.m., and after Mr. McLure arrived from New York there was a consultation between them with Mr. Szlapka. It was decided to postpone action until the morning, and to await the arrival of Mr. Birks' letter on August 28th. This decision was made almost at the moment the bridge fell.

"We are satisfied that no one connected with the work was expecting immediate disaster, and we believe that in the case of Mr. Cooper his opinion was justified. He understood that the erection was not proceeding and without additional load the bridge might have held out for days.

"Our tests have satisfied us that no temporary bracing, such as was proposed by Mr. Cooper, could have long arrested the disaster; struts might have kept the chords from bending, but failure from buckling and rivet shear would soon have occurred."

Government Exonerated.

Taking up the question of the relations of the Dominion Government with the work of construction, the Commissioners say: "The connection of the Government with the enterprise provided means for building the bridge, and final approval of plans rested with it, but in no way did the Government exercise any check on the work itself, or any authority over the contractors. The administration of the contract and disposition of the funds supplied by the Government were left entirely in control of the Quebec Bridge Company, subject to approval of the estimates by the Government inspector, and except that the quantities of material were checked at Phoenixville by a clerk appointed by the Department of Railways and Canals, and an officer of that Department visited the bridge in connection with the checking of estimates, there was no supervision on the part of the Government. By no act did the Government assume or exercise authority over the Phoenix Bridge Company, nor did it intervene under the contract for the bridge. The checking and inspection done by the Government, and above referred to, were with reference to the Quebec Bridge Company, as the agreement for financing was between the Government and the Quebec Bridge Company. The only party, therefore, who was competent to deal with the Phoenix Bridge Company, and who only did deal with it, was the Quebec Bridge Company.

"On the part of the Government its confidence in the Quebec Bridge Company was complete, in so far as the integrity of the structure itself was concerned. This was because of the presence of Mr. Cooper as the consulting engineer for the Quebec Bridge Company."

Summary.

In summing up the Commissioners say: "As a conclusion reached from the evidence, and from our own studies and tests, we are satisfied that the bridge fell because the latticing of the lower floors near the main pier was too weak to carry the stresses to which it was subjected. We also believe that the amount of these lattice stresses is determined by the deviation of the lines of centres of pressure from the axis of the chords and this deviation is largely affected by the conditions at the ends of the chords. We must, therefore, conclude that although the lower chords 9-L and 9-R anchor arm which in our judgment were the first to fail failed from weakness of latticing, the stresses that caused the failure were to some extent due to the weak end details of the chords and to the looseness, or absence of the splice plates arising partly from the necessities of the method of erection adopted and partly

from a failure to appreciate the delicacy of the joints and the care with which they should be handled and watched during erection. We conclude from the tests that owing to the weakness of the latticing the chords were dangerously weak in the body for the duty they would be called upon to do. We have no evidence to show that they would have actually failed under working conditions had they been axially loaded and not subject to transfer stresses arising from weak ends details and loose connections. We recognize that axial loading is an ideal condition that cannot be practically attained but we do not consider that sufficient effort was in this case made to secure to a reasonable approach to this condition."

Findings.

The Commissioners find that:—

(a) The collapse of the Quebec Bridge resulted from the failure of the lower chords in the anchor arm near the main pier. The failure of these chords was due to their defective design.

(b) The stresses that caused the failure were not due to abnormal weather conditions or accident, but were such as might be expected in the regular course of erection.

(c) The design of the chords that failed was made by Mr. P. L. Szlapka, the Designing Engineer of the Phoenix Bridge Company.

(d) This design was examined and officially approved by Mr. Theodore Cooper, Consulting Engineer of the Quebec Bridge and Railway Company.

(e) The failure cannot be attributed directly to any cause other than errors in judgment on the part of these two engineers.

(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.

Specifications Unsatisfactory.

(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.

Erroneous Assumption.

(h) A grave error was made in assuming the dead load for the calculation at too low a value, and not afterwards 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. This erroneous assumption was made by Mr. Szlapka and accepted by Mr. Cooper, and tended to hasten the disaster.

(i) We do not believe that the fall of the bridge could have been prevented by any action that might have been taken after August 27th, 1907. Any effort to brace or take down the structure would have been impracticable owing to the manifest risk of human life involved.

(j) The loss of life on August 29th, 1907, might have been prevented by the exercise of better judgment on the part of those in responsible charge of the work for the Quebec Bridge and Railway Company, and for the Phoenix Bridge Company.

Supervision Lax.

(k) The failure on the part of the Quebec Bridge and Railway Company to appoint an experienced Bridge Engineer to the position of Chief Engineer was a mistake. This resulted in a loose and inefficient supervision of all parts of the work on the part of the Quebec Bridge and Railway Company.

(l) The work done by the Phoenix Bridge Company in making the detail drawings and in planning and carrying out

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