Canadian Railway and Marine World.

November, 1913

Design of Large Bridges, with Special Reference to the Quebec Bridge.

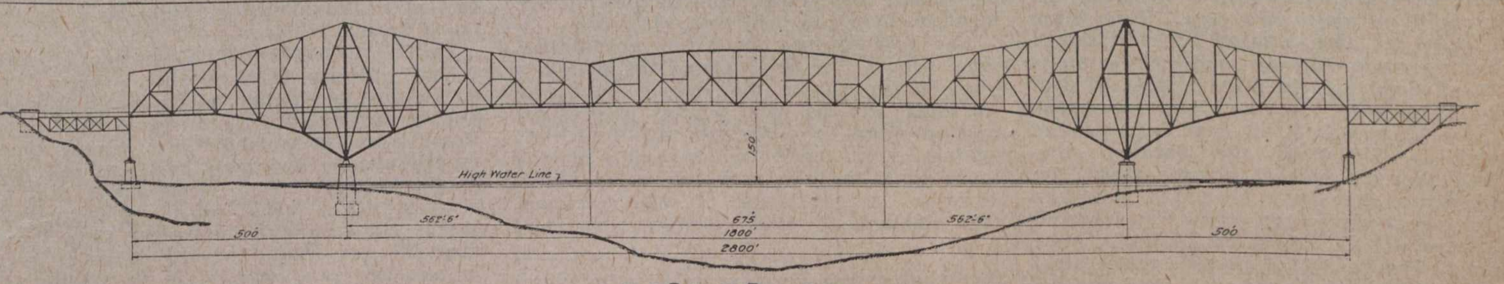
By Ralph Modjeski, C.E., Member Board of Engineers, Quebec Bridge.

Where no limitation is placed by the Government as to length of all spans, the spans should be made of economical length, provided the piers do not reduce the cross section of the river sufficiently to cause an undesirable increase in the current velocity. This economical length may be determined by trials, and will be attained approximately when the cost of the superstructure and of the substructure are nearly equal.

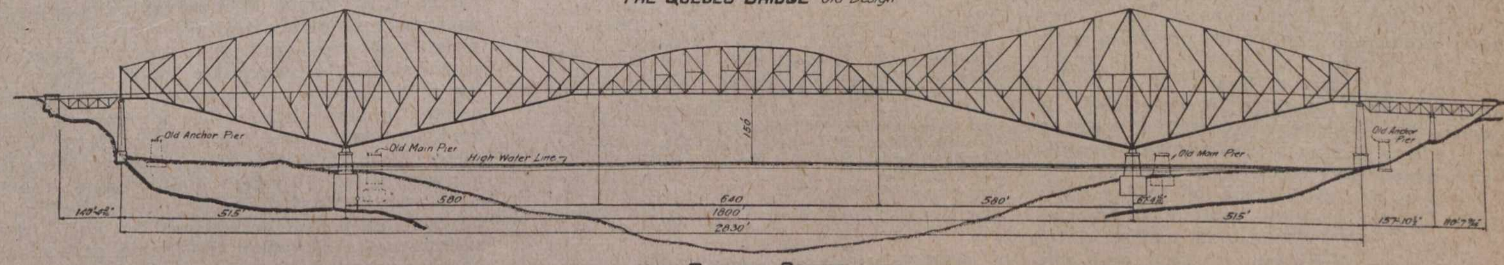
In the case of the Quebec bridge, while the navigation interests fixed the clear height of the structure above high water at 150 ft., the length of span is entirely due to the physical conditions of the crossing. The stream at this point is narrow and deep, the depth in the centre of the stream being about 190 ft. The current velocity at ebb tide is very high—about 9 miles an hour. Very heavy ice runs at times and tends to gorge. The bed rock, as shown by the borings, while accessible near the shore lines, dips rapidly toward the centre of the stream. All these conditions made it imperative to build a span of great length. The information as to bed rock which we now have would indicate that the original project could have been designed with a somewhat shorter span. Yet we should remember that this original project was undertaken by a private corporation, and we should perhaps recognize the value to it of such advertisement as the building of the longest span in the world would obviously afford. The next longest span is that of the Firth of Forth bridge, and is 1,700 ft. long. It is doubtful if a shorter span than 1,700 ft. would have been practicable at the location adopted for the Quebec bridge. I consider it perfectly legitimate to build a more expensive structure than economy of the work itself would call for, if the more expensive structure will afford sufficient advertisement and publicity to compensate for the additional expenditure. Cases also often arise where a purely economical and utilitarian structure would be entirely out of harmony with the surroundings.

A project to build a large bridge at Quebec, presumably in the same location as the present one, was seriously considered in 1884 and 1885. James Brownlee, A. Luders Light, and T. Claxton Fidler designed a structure with a clear span of 1,442 ft. The description of that project mentions rock foundations. The more complete information we now have, and which was obtained by a costly series of borings, shows that at the present location rock could not have been attained in both piers with any known method of foundation if the piers had been spaced only 1,442 ft. apart, even if the great depth of water could have been overcome.

After the disaster of Aug. 29, 1907, the Dominion Government took up the reconstruction of this bridge. A board of three engineers, including myself, was appointed to design and construct the bridge. After some study of the situation, the board decided that the new bridge should be made wider between trusses and designed to carry heavier loads than those originally contemplated; that, further, none of the old steel work could be used to advantage. It also decided to keep the same location. The final outcome is a double track span 1,800 ft., with a width of 88 ft. between centres of trusses, designed to carry on each track a live load consisting of two E 60 engines placed in any position in a train weighing 5,000 lbs. per foot so as to produce greatest strains. The old piers were not large enough for the new design and could not, therefore, be used. At first the board contemplated building an entirely new pier 57 ft. south of the present north pier, and enlarging the foundation of the south pier by sinking additional caissons adjacent to the old caisson. The necessary span length would then have been 1,758 ft., and it was on that length of span that tenders were asked. It developed later, from the experience of sinking the north caisson, that the method proposed for enlarging the south foundation would not be safe, even if it were practicable, and so an entirely new foundation and pier were decided on for the south shore. The new north pier could not be placed further out in the river because of the sloping bed rock and great depth of water. The south pier could not be placed on the north, or river, side of the old south pier because of the old wreckage, so it was placed 64 ft. 8 in. south of the old pier, or as close as possible to it. Both new piers being placed 64 ft. 8 in. south of the old piers, measured between centres, the new span remains 1,800 ft. long.



THE QUEBEC BRIDGE Old Design



THE QUEBEC BRIDGE New Design

Substructure.

The piers are all of granite, backed with concrete. There is an increasing tendency now to build everything of concrete. Certainly, concrete is a most convenient material and quite economical. When it comes, however, to providing supports for a very important and expensive structure, cut stone masonry should be used in preference to concrete, except for backing. There are many varieties of excellent building stone on this continent. I have used granite, some varieties of oolitic limestone, also sandstone, which all show excellent lasting qualities in works constructed many years ago, while concrete presents some uncertainties and requires expert care to give good results. Concrete may in ages prove to be as lasting as stone masonry, but as yet we do not know. We know that well constructed stone masonry will last for centuries. A notable example of this is the great Aqueduct of Gard, built by the Romans in the first century B.C.

TYPES OF SUPERSTRUCTURE.—Having fixed the span lengths of a bridge, the next thing to determine is the type of superstructure to be used. The various types usually applied to long spans may be classi-