span of a cantilever bridge which has ever been lifted into place. It is the first span ever hoisted by hydraulic jacks, and is by long odds the largest span of any kind which has ever been hoisted.

A number of simple spans on falsework have been floated at high tide and lowered into position on their piers with the fall of the tide, but the Quebec Bridge span is the first span of a cantilever bridge that has ever been floated on scows, and it is considerably larger than any other span of any kind which has ever previously been floated. The next largest span ever floated, so far as we are aware, was the Hawkesbury Bridge in New South Wales, a 420-ft. simple span which was floated into place on high scaffolding at flood tide.

It is problematical whether the success of the Quebec Bridge will lead to any extensive use of the K-system for smaller bridges. The bridge engineer of the Sante Fe Railway recently adapted the system to a simple span between 300 and 400 feet long, and we understand that the design in this case did not prove to be economical. The economy of the K-system due to each diagonal taking only half the web shear may be lost if the span be such a light one that it is better to concentrate the shear in one diagonal than to try to divide it between two members. But for cantilever bridges with long spans, the Quebec Bridge has proven the complete superiority of the K-system.

Many scientific points of design which have hitherto been totally ignored or very indefinitely determined has to be most carefully calculated for the Quebec Bridge on account of the extraordinary proportions of the structure. The friction breaks, for instance, between the cantilever arms and the suspended span are very unusual. It was calculated that a friction of 250,000 lbs. would be required at each corner of the suspended span to prevent its being swung back by a locomotive or by longitudinal wind force. Provision had to be made to get this friction and yet permit the span to expand or contract before the stresses due to temperature changes could become too large. As a result of much study, friction plates have been inserted which can be adjusted initially, and from time to time, to give any desired friction, a hydraulic arrangement has been devised for pulling out a test plate at any time and measuring the amount of friction which must be overcome in doing so, and by a screw adjustment the friction can be increased or decreased as may be found necessary and the other plates similarly adjusted. There are about a dozen of these friction plates at each end of the bridge, fitting into each other much as would the fingers of levelly outstretched interlocking human hands. The rails or track are in no way depended upon to keep the suspended span from moving.

Many other similar points which have been previously largely ignored in bridge design, have been most carefully calculated. As another example, there is a very unusual contrivance at the anchor pier, where the big lengths and sections involved make the motion at the pier a very complicated one.

Cross-winds bend the anchor span in a horizontal plane, while live loads bend it in a vertical plane, and also the end struts may rise or fall either levelly or unevenly with the expansion and contraction of the anchor chains, which may or may not be uniform, and at the same time the motion tending to distortion, due to train on one track, must be considered. This means that motion of practically every describable description must be provided for at one point. Therefore, there has been imbedded in the anchor piers a deep steel frame, carrying a vertical pin, and at the end of the pin there is a spherical thimble that allows vertical motion as the thimble slides up and down on the pin, and longitudinal motion as both pin and thimble slide between vertical plates, and any other kind of motion on account of its spherical shape. This new type of joint is situated at the centre of the bottom end strut of each anchor arm, and may be said to be a combination of universal hinge and sliding joint. This complicated motion is partly due to the unusual length of the span and the great length of the anchor chains, and partly to the heavy trains for which allowance has been made.

Temperature stresses were without doubt never before so carefully calculated. A difference of 25 degrees in temperature was assumed between the parts exposed to the sun and the shaded parts. Between the piers and the bridge proper a difference of 50 degrees temperature was considered. Secondary stresses of all sorts were considered and allowed for in an unprecedented manner. Needless to state, the weight of the paint and every other known feature of dead weight, however slight, was taken into consideration.

Only stresses due to the absence of pins at joints or due to friction at pins, were considered as secondary stresses, the wind and all other stresses being considered primary. For compression members, primary stresses were not permitted to exceed 14,000 lbs. per sq. in., or 18,000 lbs. per sq. in. inclusive of all secondary stresses. For eye-bars, tension, 20,000 lbs. per sq. in. was allowed for primary stresses, and 24,000 lbs. per sq. in. inclusive of all secondary stresses. For riveted tension members, 18,000 lbs. per sq. in. was allowed for primary stresses and 24,000 lbs. per sq. in. inclusive of all secondary stresses. In this regard one must remember that the K-system eliminates most of the secondary stresses, and the greatest secondary stress can never co-exist with the greatest primary stress.

Probably no other bridge has ever been erected so carefully as has the Quebec Bridge. The sections were put into place one at a time, every main member being riveted as the work progressed. The plans for the erection of the centre span received the best care and thought from many of the most experienced bridge engineers in Canada and the United States. When one looks at the tremendous centre span and sees the great height to which it must be lifted, one is inclined to say that it will be a miracle if the bridge is ever successfully completed. Even a comparatively brief study of the plans, however, serves to show that every minutest detail has been so carefully calculated that one readjusts his opinion and decides that it would be a miracle if the suspended span were not to be readily hoisted into place exactly as planned.

The accident of last year was very unfortunate, yet it is hardly to be expected that such an enormous undertaking could be carried out without more or less serious accident, and the accident that did happen chanced to be of the more serious type. The same care has been taken in regard to the lifting appliances as was shown in the design of the bridge proper. For instance, due allowance was made for the difference in length between the various lifting chains due to the fact that certain chains might be in the sun and others in the shade.

The suspended span has been designed to permit of a torsion of about 3¼ inches in diagonally opposite corners. For example, if the southwest and northeast corners of the span were to be held steady while the southeast and northwest corners were both to be dropped or both to be raised simultaneously to the extent of about 3¼ inches,