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On Arch Bridges with Inclined Hangers.

Über Bogenträger mit schräg gestellten Hängestangen.

Sur les ponts en arc avec suspentes obliques.

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In his interesting paper on new considerations arising in the construction of large reinforced concrete structures M. *Boussiron* has drawn a number of conclusions which, in the opinion of the present writer, are not capable of justification.

He makes a comparison between the self-stable arch at La Roche Guyon and the arch with inclined suspension bars in the Castelmoron bridge, and suggests that, for various reasons, the latter system of construction is unsuitable for spans in excess of about 150 m. It would appear from this that the true working principle of the system with inclined suspenders has not been quite understood by M. Boussiron, for the question is not one of a parabolic lattice girder with triangular mesh in which the web members must not carry compression, but of an arched construction wherein the effect of the alternating inclined arrangement of the suspenders is greatly to diminish the moments. This working principle holds good even if all the suspenders sloping in one direction cease to operate, and even in such a case the moments are very considerably less than in the corresponding arch of the ordinary type.

The firm of Christiani and Nielsen have constructed such arches in large numbers, including three structures with spans of over 100 m, the largest example being the Castelmoron bridge mentioned by M. *Boussiron* in his paper. In the course of designing these bridges it has in fact been found that the type of arch with inclined suspension bars is not so well adapted for small spans and that its full advantages are realised only in really large spans. When it is mentioned that in the main arches of the Castelmoron bridge, which is a road bridge for heavy traffic, with a span of 143 m and a distance of 8.5 m between centres of main girders, the dimensions at the crown are only 100 by 120 cm, it is difficult to suppose that even here the system has reached its limit of possible application. Designs for larger spans up to more than 200 m have been worked out on several occasions and there appears absolutely no obstacle to the construction of such bridges in still larger spans.

The effectiveness of the system depends not only on the inclination of the suspension bars but also, to an important extent, on the proportion of live to

dead load. Its advantage increases with the relative importance of the dead load, and since it is the latter, not the live load, that grows with the span, the most favourable conditions are realised only in large spans.

The inclination of the suspenders will not, of course, be reduced progressively with the increase in span as M. *Boussiron* assumes. On the contrary, there is a certain optimum inclination from which one should not deviate more than can be helped, and in the very large spans it may be necessary for the suspenders to cross one another — an arrangement which would be perfectly feasible, though it has not been necessary in the bridges actually constructed up to the present time.

For further details reference may be made to the paper by *Dr. O. F. Nielsen*, the inventor of the system, printed in the first and fourth volumes of the "Publications" of the I.A.B.S.E.