Some details about the erection of steel arch bridges

Autor(en): **Roggeveen, A.**

Objekttyp: **Article**

Zeitschrift: **IABSE congress report = Rapport du congrès AIPC = IVBH Kongressbericht**

Band (Jahr): **3 (1948)**

PDF erstellt am: **27.04.2024**

Persistenter Link: https://doi.org/10.5169/seals-4034

IIIc

Quelques détails sur le montage des ponts en arc métalliques

Einige Angaben über die Montage stählerner Bogenbrücken

Some details about the erection of steel arch bridges

PROF. IR. A. ROGGEVEEN
Wassenaar (Hollande)

A stiffened flexible arch bridge with the arch above the stiffening girder can be erected in very much the same way as an ordinary beam bridge, i. e. on a large number of jacks, either hydraulic or screw jacks, resting on a centering under the entire length of the bridge. On these supports the stiffening girder and the system of floorbeams are laid out and by jacking the designed camber is obtained.

On top of the stiffening girders the hangers are erected and on these the arches. By means of the jacks care is taken that throughout these operations the right camber, computed for the unstressed condition, is maintained.

Thereupon the holes for the fieldrivets may be reamed in the arches and in the stiffening girders after which the rivets can be driven and when this has been done the bridge is gradually jacked down until it carries its own weight.

For this type of erection a large number of supports has to be placed in the river or whatever the bridge has to cross. In the case of a navigable stream, this may entail closing the fairway to traffic or building over at least part of it an erection-bridge, on the top of which the permanent bridge can be built.

In such an instance a stiffened flexible arch bridge may have advantages, as this type of bridge can be made to work as its own erection bridge, thus avoiding the need for a separate one. By doing so there is an added advantage, as by concentrating the erection supports at a few points the total cost of supports is usually considerably less, due to the fact that it is far easier to obtain sufficient stiffness for one large support than for a number of supports which, together, are supposed to carry the same load as the large one.

To achieve this, however, numerous precautions have to be taken in order to obtain a perfect camber in the completed structure. These precautions are fairly simple and are all intended for the same purpose, viz. to place the stiffening girder and the arch, though both are stressed, in such a manner that these parts would return to a camber computed for unstressed condition, if the existing stresses could be eliminated. Yet experience shows that often a great deal of arguing is necessary to convince people that this method of erection really works out all right and it may be useful to describe this method, adding that it has been used in the Netherlands so far thrice, namely twice for a 122 m span across the Geldersche Yssel at Deventer (1942 and 1947) and once for a 120 m span across the Rhine at Arnhem (1943), with perfect results.

In both cases the bridge was erected on its own end supports and only two intermediate supports, the location of which was chosen so as to allow sufficient width for navigation. These intermediate supports brought the over-all height to length ratio of the stiffening girders, respectively amounting to about 1 : 37 and an average of about 1 : 31, down to about 1 : 16 and 1 : 12. Though these ratios are not unusual for continuous girders over four supports, the girders deflect noticeably under their dead weight and that of the parts of the bridge they have to support during erection.

The easiest way to achieve at least part of the above mentioned purpose would be to erect the stiffening girders above the solid ground in the neighbourhood of the erection site, giving the girders as many supports as needed to assure the right camber, then to rivet the composing parts together and to put them on their supports in one piece. However the girders were rather flexible laterally and moreover rather heavy (230 t and 330 t respectively), which would mean strong erection equipment, and so it was thought feasible to erect them in three parts, one on each side from the end support till past the intermediate support and a closing piece in the middle, which pieces could be handled easily by floating cranes.

These three pieces were also made on the bank of the river and, though theoretically it is possible to compute the true position the two end parts have to be put in to get the connection with the middle part in the right position for reaming, it was decided to do this reaming between the three parts on the bank of the river too, as this work is done there under better circumstances and moreover the matter of obtaining the right camber, without flaws, is a rather delicate one, which can easily be spoiled by a miscalculation.

Thus, when these holes are reamed beforehand, it becomes only a question of jacking on the intermediate supports with the middle part hanging in a crane until these holes come to a perfect fit, in which position they are held by pins and bolts till the riveting of the joint is done. In order to obtain enough lateral stiffness, floorbeams and windbracing were put between the main girders, immediately after erecting these.

After the riveting of the joints is done, the girders are brought on their four supports to their true elevation, but naturally they deflect in between; a rough idea of their deflected shape is shown in fig. 1.

Now the hangers are erected on top of the stiffening girders on fills of such thicknesses as the deflections of the stiffening girders are expected to become after carrying the additional weight of hangers, arch, upper

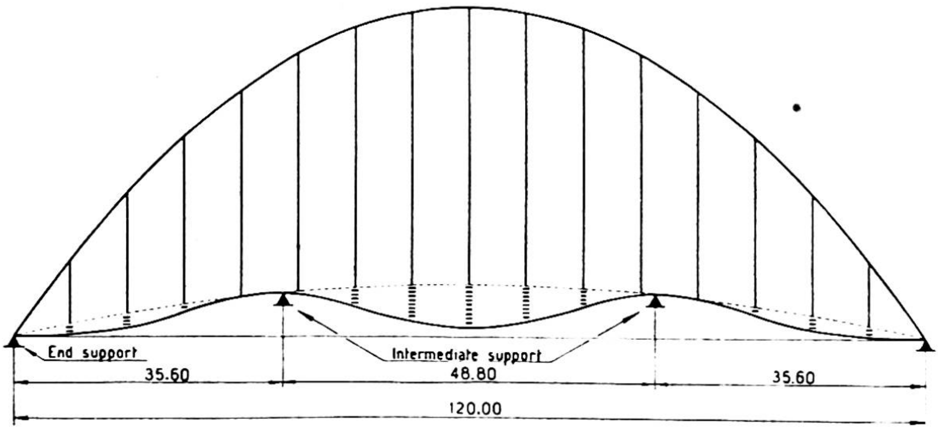

Fig. 1.

wind bracing, etc. After bracing the hangers, if necessary, the arch and its wind bracing are erected on top of these. As the stiffening girder, without its deflections, would be in the right form for an unstressed condition, this means that due to these fills between the hangers and the girders, the arch is now brought in the shape it is supposed to have in the unstressed condition. After checking this true camber of the arch, which can easily be done by leveling computed marks put on the hangers at a convenient elevation, the joints in the arch may be reamed and riveted.

This being done, the fills under the hangers may be removed, doing which the arch, being far more flexible than the stiffening girder, assumes an additional curvature conform to that of the deflection of the stiffening girder; consequently the hangers settle down on this girder and the connections between these two can now be reamed and riveted.

The main girders of the bridge are now more or less in the shape shown in fig. 2, but due to the fact that both the stiffening girders and the arches have been reamed in the true form for unstressed condition, upon jacking down on the intermediate supports the girders will deflect in such a way that, if the preliminary computations have been accurate, the bridge will show a perfect camber without even the slightest tendency to irregularities, not even at the former intermediate supports. Neither have an irregular way of erecting the bridge, such as omission of all of the floor beams only in the middle part of the bridge or putting the intermediate supports under the two girders not in the same cross-section but on a skew, owing to the bridge crossing the navigation channel under an angle

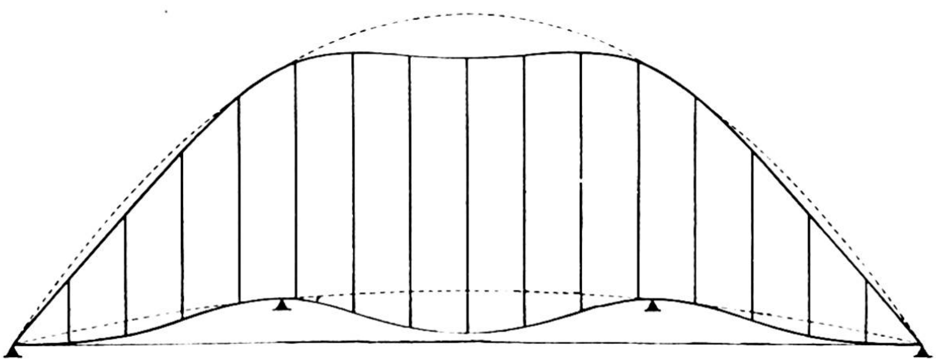

Fig. 2.

differing from 90 degrees, any effect on the camber, which has been proven in practice, as long as the leading principle is carried out conscientiously namely reaming and riveting both the stiffening girder and the arch in the shape computed for the unstressed condition.

An erection problem that has some resemblance to the one mentioned above, though its basis is quite different, shows up in the erection of a three-hinged arch with tie. Though the final state of bridges of this type in the Netherlands usually is that of a two-hinged arch with tie, they are erected as three-hinged arches with an extra hinge in the top in order to eliminate stresses due to slight errors in the length of arch and tie and to settling of the abutments. After the bridge carries its entire dead load, this extra hinge is closed, transferring the system to a two-hinged arch.

A three-hinged arch has the rather disagreeable quality of having a practically triangular deflection diagram, so when erecting the bridge in a for this type conventional way, i. e. on a continuous centering, first the ties and the floor system, then the hangers and on top of these the arch, upon jacking down only the angle between the two halves of the bridge between the abutments and the hinge in the center changes, but the two halves themselves remain practically straight. This does not effect the arch as it has a hinge in the top, but because a hinge in the tie would be far more complicated than one in the arch, the former is usually omitted and consequently the tie is bent sharply in the panel under the arch hinge. As the tie naturally has a certain stiffness, bending stresses are the result of this. These stresses can be considerable and would have amounted e. g. for the main span of the bridge across the river Noord at Hendrik-Ido-Ambacht, which has a length of 184^{m}80, to about 500 kg pro sq. cm. This is of course a secondary stress, which would disappear by flowing of the material of the tie, if this were stressed above the elastic limit by the combination of this bending stress and the normal stresses where the tie is meant for. However, it is good practice to avoid such high secondary stresses wherever this is possible and in this case we can do it with rather simple means.

We object to the stresses resulting from a downward bending of the tie, so if we can manage to give the tie an equal upward bending before building it into the bridge, the result will be : no bending stress.

This can be accomplished by erecting the middle section of the tie at first separately from the parts at both ends of the bridge. This separate part had in the above mentioned bridge a length of about 60 m and was devided lenghtwise in seven pieces. These were layed out in the usual way, except for the fact that the direction of the two ends, each consisting of three pieces which were in respect to each other in the computed camber for unstressed condition, differed as much from that camber as the computed angular change of the two halves of the bridge going from the unstressed to the three-hinged condition, as shown in fig. 3. In this position the joints between the seven pieces were reamed and riveted and after this

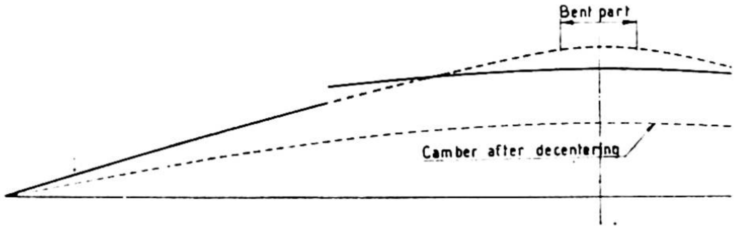

Fig. 3.

the two ends were jacked down to the position assigned to them during erection. This gives the middle panel an upward bend, which causes, not only in this panel but also in the neighbouring panels, stresses that are exactly equal to but opposite in sign to those that will be caused later on by decentering the bridge in three-hinged-condition. There is no necessity for downward forces to act on the tie to obtain this bending of the middle panel, as the dead load of the tie is quite sufficient to reach this aim.

Following this the two ends of the thus stressed tie are connected to the other parts of the tie and from here on the erection proceeds in the usual way.

When the bridge is finally decentered the built-in bending stresses will disappear by superposition of those of opposite sign and the result will be a tie with practically none but normal stresses.

Résumé

1. Montage de ponts en arc renforcés utilisant peu de supports intermédiaires, espacés à 40 mètres et plus.

2. Procédé de montage d'un arc à trois articulations avec tirant évitant les grands efforts de flexion secondaires dans ce tirant en dessous de l'articulation supérieure.

Zusammenfassung

1. Montage versteifter Stabbogen (Langer'sche Balken) unter Verwendung weniger Zwischenstützen in 40 oder mehr Meter Entfernung voneinander.

2. Methode zur Errichtung eines Dreigelenkbogens mit Zugband unter Vermeidung hoher zusätzlicher Biegebeanspruchungen im Zugband unter dem oberen Gelenk.

Summary

1. Erection of stiffened flexible archbridges using few intermediate supports at distances of 40 meter and over.

2. Method of erecting a three hinged arch with tie avoiding high secondary bending stress in the panel of the tie beneath the top-hinge.

Leere Seite
Blank page
Page vide