Girder bridges of large span in reinforced concrete

GIRDER BRIDGES OF LARGE SPAN IN REINFORCED CONCRETE

PONTS A POUTRES EN BÉTON ARMÉ DE GRANDE PORTÉE

WEITGESPANNTE BALKENBRÜCKEN IN EISENBETON

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It has become the custom to classify bridges into types, according to the form and supporting conditions of their principal carrying members. The type known as girder bridges usually infers structures comprising solid web beams sensibly uniform in depth and with vertical supporting reactions.

There are many examples of such girder bridges having spans of say 50-ft. (15 metres) and under, but they have no particular significance in bridge engineering.

Certain requirements in the matter of spacing of the beams and the general arrangement have to be considered in such cases, but the lay-out is principally governed by the intensity and form of loading for which the bridge is to be designed. In principle, however, such considerations are equally applicable to the design of reinforced concrete floors.

Where the spans are greater than 50-ft. (15 metres) members of various forms, all of which come within the category of girders, are met with in actual practise, notwithstanding the fact that in some cases quite different problems in design are created and the actual appearance of the structure is very far removed from what is generally regarded as a girder bridge. The bridges shown in Illustrations Nos. 2 and 5 are examples of this difference.

A large number of reinforced concrete girder bridges of different types, with spans of from 50-ft. (15 metres) to 150-ft. (45 metres) have been erected in Great Britain — a few of them as early as the year 1904 but the majority since 1920.

There have been no girder bridges erected in Great Britain which compare in size with some of the examples to be seen in France and elsewhere.

The largest span girder known to the authors is the Rue Lafeyette Bridge in Paris which spans the railway near the Gare de l'Est. The girders of this bridge are of the lattice type and the largest span 250-ft. (76 metres).

This bridge differs considerably in arrangement and appearance from those previously mentioned, from which it may be observed that even in a paper limited to girder bridges, only the briefest reference to particular structures is possible.

Most of the bridges referred to as having been erected in Great Britain are roadway bridges carrying vehicular and pedestrian traffic. The more recent have been designed to carry the standard train of loads laid down by the Ministry of Transport.

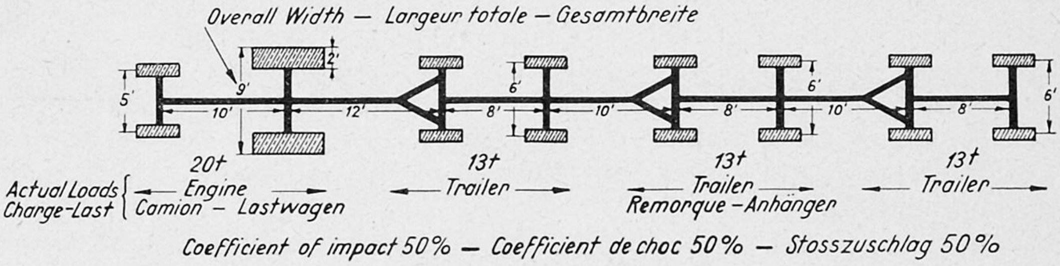
As will be seen from the accompanying diagram this loading is heavy, involving wheel loads of 11-tons, and has resulted in the building of bridges much stronger than required for general present day traffic.

A concession in this loading has been recently granted, so that future bridges will have a lesser reserve of surplus strength than hitherto.

The point is mentioned because of the satisfactory manner in which the older structures, which were not designed for such heavy loading, are carrying all kinds of modern roadway traffic.

The composite and yet at the same time monolithic nature of reinforced concrete makes the calculations of the working stresses a problem of great interest to Engineers with a liking for mathematics. There is, in consequence, a developing tendency to increase the complexity of mathematical analysis, particularly for girder bridges and continuous arches.

These refinements in design are to be welcomed, but it is sometimes doubtful whether the more complicated methods give in practise better results than the application of much simpler formulae.



Compare note on page 35 — Comparez la remarque à la page 35 — Siehe Bemerkung Seite 35.

For this reason the authors think that some useful lessons may be gleaned from the inspection of works built twenty or thirty years ago, when the theory of reinforced concrete design was only imperfectly understood and the principles on which designs were based were not developed to the extent they are to-day.

This is not to decry academical study or to deprecate the advantage of the greater experience and technical knowledge available to-day, but rather to show the inherent quality and suitability of reinforced concrete for the type of structure under review.

An example of one of the early bridges referred to above is shown in Illustration No. 2 and described later.

With the very considerable increased strength of concrete to-day, resulting principally from the general improvement in the manufacture and quality of modern cement, higher concrete compressive stresses are being permitted in design.

For bridge members subject chiefly to compression, such as columns and arch members, these higher stresses can be adopted without qualification, and with economical advantage. For girder bridge construction, however, where the principal members are subject primarily to bending, the very important question arises as to the increase in shearing and bond stresses to be permitted.

Although shearing stresses are frequently regarded as being of somewhat lesser importance than the direct tensile and compressive stresses, it is the authors' experience that visible defects manifesting themselves in members of a structure are usually traceable to excessive shear.

For this reason the question of increasing the shear stress on concrete in direct proportion to the increase in compressive strength, should be approached with caution. Even greater caution should be taken in considering the increase to be permitted in the limiting shear stress on a section inclusive

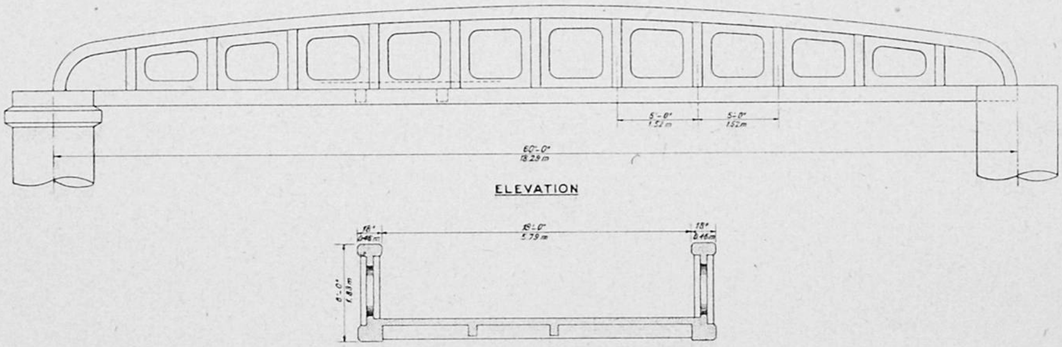


Fig. 1.

of the steel reinforcement because in this case the adhesion between the latter and the concrete is involved.

The profile of a girder bridge is often governed by the available space required under and the gradient of the approaches on either side of it. As a result it may be found that the depth of the whole or a portion of the main

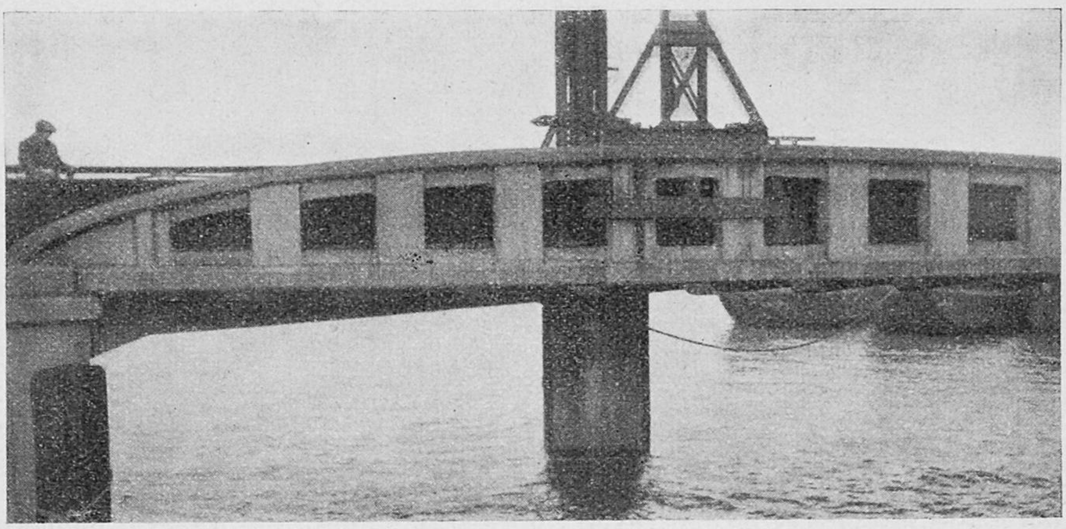


Fig. 2.
Girder Bridge at Purfleet — Pont à poutre à Purfleet — Balkenbrücke in Purfleet.

girders is less than would be adopted were there no such restrictions. The accomodation of the shearing stresses induced in such cases becomes of considerable importance in the design.

The adoption of one or another of the types of girder bridges already mentioned results from either the necessity of conforming to requirements fixing the profile, the existence of supports or suitable locations for them, the angle of skew, or other exigencies of the site too varied to mention.

In the design of each type, however, there are usually one or more important points to be considered, and in the following brief description of girder bridges it may be of interest to draw attention to these points.

Girder Bridge at Purfleet.

This bridge, which has already been referred to, is shown in Illustrations Nos. 1 and 2, the principal members being 60-feet (18.30 metres) span open web girders. It carries coal trucks and locomotives on to a large jetty at Purfleet on the River Thames.

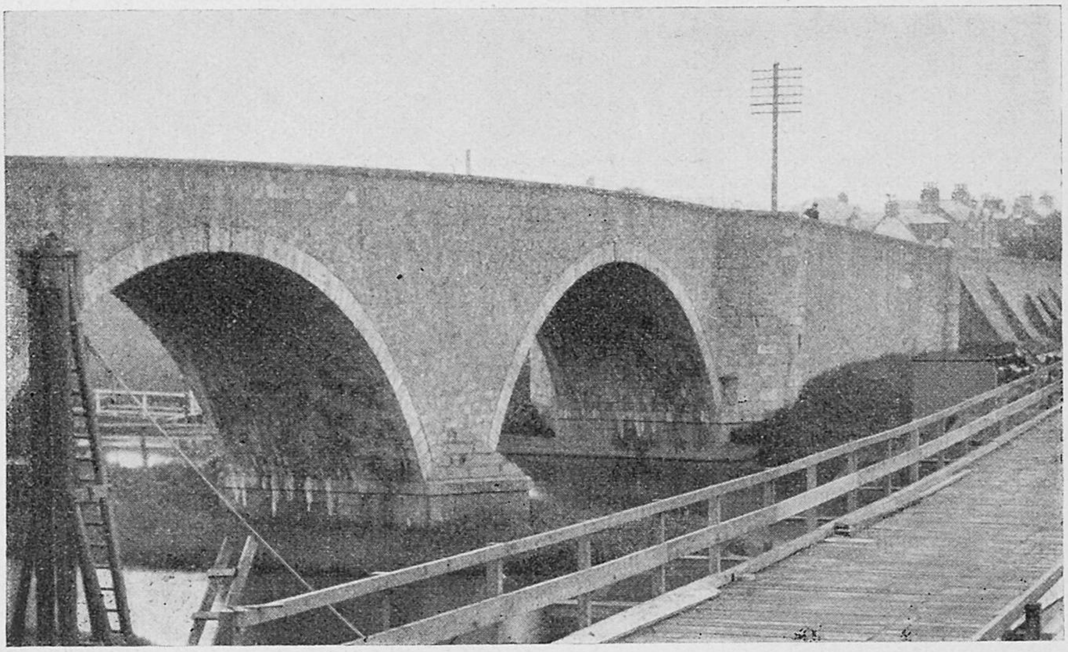


Fig. 3.
Old Bridge over the River Don — Ancien pont sur le Don — Alte Donbrücke.

Although built in 1904, probably by less efficient workmen and certainly with lower strength concrete than now obtainable, it meets present day requirements with complete satisfaction.

The calculations and details of the reinforced concrete in this bridge were prepared by the late Mr. L. G. Mouchel, who was one of the pioneers of reinforced concrete in Great Britain. An inspection of the detail working drawings show that although there are some details of the reinforcement which could nowadays be improved by rearrangement, the general conception is extraordinarily up-to-date, and the bridge functions perfectly. Nevertheless, it is practically certain that the theoretical work on which the design was based must have been of a much more elementary character than would nowadays be devoted to such a structure.

Bridge over the River Don, Scotland.

This is a three-span girder bridge 217-feet (66 metres) long and 35-feet (10.66 metres) wide between parapets, and is illustrated in Figs. Nos. 4 and 5. It is built on the supports of the original masonry structure which it replaces.

The old bridge consisted of masonry arches and had steep approaches, as will be seen from Fig. 3, but although the height of waterway to be maintained in the new structure was considerable, it was found possible, with a special girder bridge construction, to provide practically a level roadway throughout — a very slight gradient only being necessary in order to connect with the existing roadways on either side of the river.

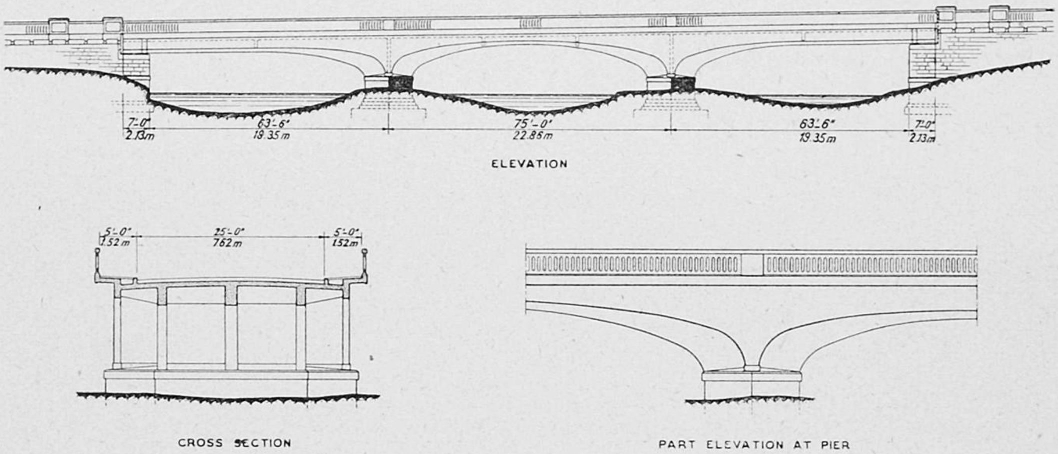


Fig. 4.

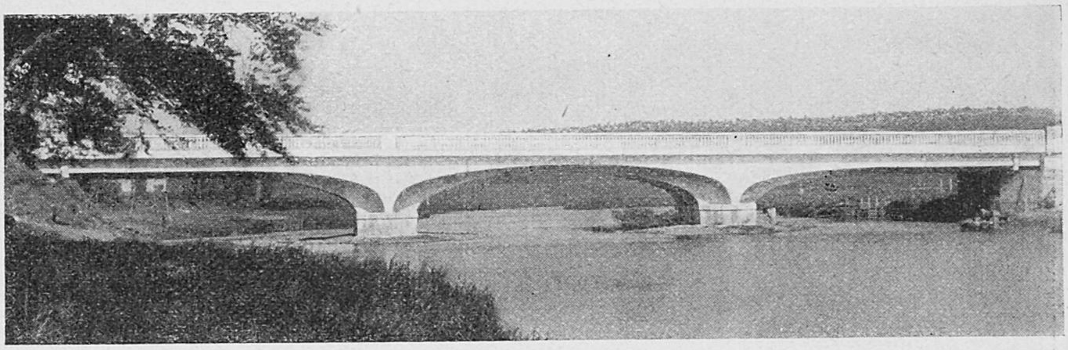


Fig. 5.
New Bridge over the River Don — Nouveaux pont sur le Don — Neue Donbrücke.

To eliminate the excessive tension that would otherwise have been induced in the lower reinforcement, the ends of the side spans were supported on wedges which, upon the completion of the superstructure, were removed, thus allowing the extreme ends of the girders to descend on to their bearing plates and thereby producing an initial negative bending moment of the requisite amount in the centre span.

George V Bridge — Glasgow, Scotland.

The profile of this bridge was fixed in all respects by natural and specified conditions.

It is 80-feet (24.40 metres) wide between parapets and approximately 430-feet (131 metres) long, with a centre span of 166-feet (50.60 metres) and side spans of approximately 130-feet (39 metres) each.

The river piers and abutments are supported on circular concrete caissons founded about 80-feet below roadway level.

At the river piers the superstructure is supported on steel roller bearings inclined so that its movement is a circular rotation about the centres of the caissons at foundation level, this ensuring uniform ground pressure.

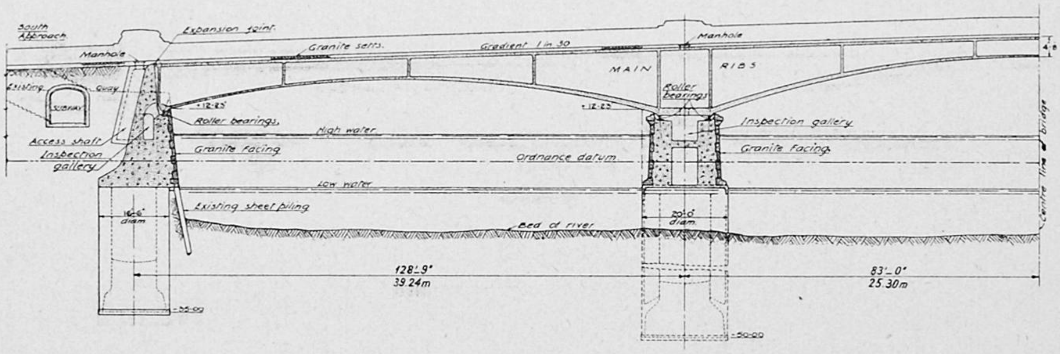


Fig. 6.

Steel roller bearings are also provided at the abutment supports, these being slightly inclined so that the horizontal reaction to some extent opposes the overturning tendency of the abutment, produced by the earth filling retained. With this bridge also the depth of construction at the centre was so small that excessive tension was likely to be produced.

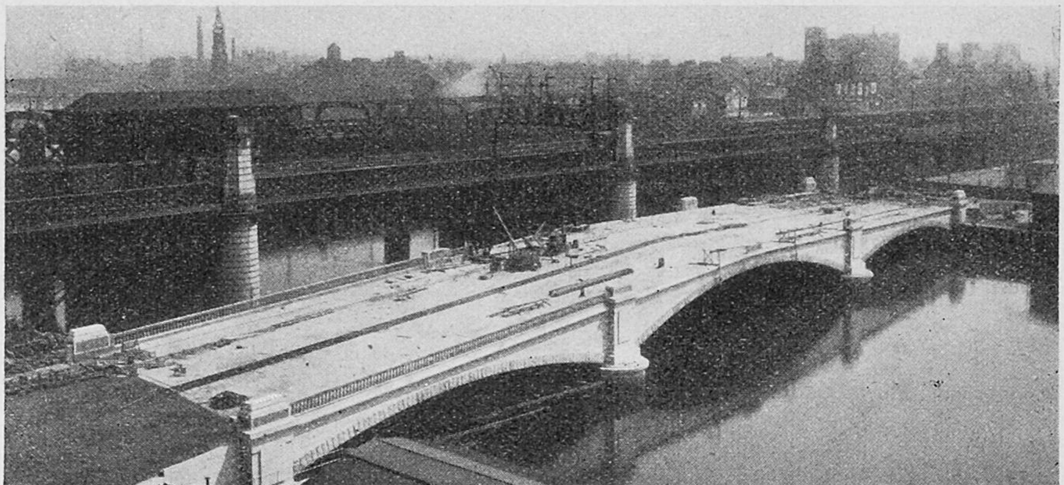


Fig. 7.
George V Bridge — Pont George V — Brücke des Königs Georg V.

To prevent this a transverse strip of the superstructure at the middle of the centre span was temporarily omitted until the staging for the remainder had been slackened. In this way no stresses were produced in the centre of the superstructure, due to the weight of the work itself.

Until this transverse strip was concreted the two halves of the bridge were in a static condition, so that any slight relative settlement of the supports, due to the dead weight of the structure, could take place without the introduction of unknown strains into the superstructure.

The train of loads specified to be carried on the roadway was very heavy. It comprised a load of 120-tons, carried upon a trailer with four wheels and drawn by five tractors, each weighing 15-tons.

Illustration No. 6 shows a half longitudinal section of the bridge and indicates generally the arrangement adopted.

Illustration No. 7 shows the finished bridge.

Summary.

The Authors point out that no very large girder bridges in reinforced concrete have yet been constructed in Great Britain, and it is necessary to go to the Continent for outstanding examples of this type.

The paper includes a general description with photographs and diagrams of several bridges, and also discusses the origin of certain visible defects which occasionally manifest themselves.

It expresses the view that although the modern refinements in theoretical design are to be welcomed, it is sometimes doubtful whether these more complicated methods give in practise better results than the application of much simpler formulae.

An examination of some of the early bridges indicates that the majority of defects which have developed are attributable to the practical considerations of workmanship and materials rather than to the absence of meticulously accurate theoretical treatment in the design.

Résumé.

Les auteurs attirent l'attention sur ce fait que l'on n'a pas encore construit, en Grande-Bretagne, de très grands ponts à poutres en béton armé. Ce n'est que sur le Continent que l'on peut trouver des exemples caractéristiques de ce mode de construction.

Ce rapport donne une description générale du système, ainsi que des photographies et schémas se rapportant à différents ponts; on y trouve une discussion de l'origine de certains défauts qui se manifestent visiblement dans certains cas.

Les auteurs, tout en reconnaissant que la conception théorique de ce dispositif peut encore faire d'intéressants progrès, estiment douteux que ces méthodes en somme assez compliquées puissent, dans la pratique, donner de meilleurs résultats que l'application de méthodes plus simples.

L'examen de quelques-uns des premiers modèles construits montre que la majorité des défauts qui se sont manifestés doivent être attribués à des considérations pratiques, telles que la qualité de la main d'oeuvre et des matériaux, plutôt qu'à une précision insuffisamment poussée dans l'établissement des projets.

Zusammenfassung.

Die Autoren zeigen, daß in Großbritannien bis jetzt keine sehr großen Balkenbrücken in Eisenbeton erbaut worden sind, so daß man die dort fehlenden Beispiele für diese Bauart auf dem Kontinent suchen muß.

Die Abhandlung enthält eine allgemeine Beschreibung mit Photographien und Entwürfen von verschiedenen Brücken. Sie erörtert auch die Ursachen von gewissen sichtbaren Mängeln, die diesen gelegentlich anhaften.

Die Autoren sind der Ansicht, daß, wenn auch die moderne Verfeinerung der Berechnungsweisen zu begrüßen ist, es doch manchmal zweifelhaft erscheint, ob diese komplizierten Methoden in der Praxis bessere Resultate ergeben als die Anwendung von einfachern Formeln.

Die Prüfung einiger der ältesten Brücken ergibt, daß der Ursprung der meisten sich zeigenden Fehler mehr auf der praktischen Seite (Baustellenarbeit und Materialbeschaffenheit) und nicht im Fehlen einer genauen, theoretisch einwandfreien Berechnungsmethode zu suchen ist.