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Autor: Gottfeldt, H.

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Pont sur le Derwent River, près de Hobart (Tasmanie)

Brücke über den Derwent bei Hobart (Tasmanien)

Bridge over the River Derwent near Hobart (Tasmania)

D[r] ING. H. GOTTFELDT, M. I. STRUCT. E.
London

The bridging of a wide river is in itself a fascinating problem for the structural engineer. The width is the most manifest obstacle, but there are usually many others, less obvious but equally hard to conquer. Wide rivers are frequently of a commensurate depth, perhaps of several hundred feet, and even at that depth the river bed may be utterly unsuitable to support the weight of a bridge pier. Currents, tides, and atmospheric conditions will have to be considered. Last, but not least, the demands of the traffic *across* the river are usually diametrically opposed to those of the navigation *along* it; if the surrounding country side is fairly flat the road user or railway engineer will ask for a crossing a few feet above the water level, so as to avoid the expenditure of money and energy on the climbing of long ramps, while sea-going ships require a clear headroom of 150 feet and more and, of course, a corresponding clear width.

All these difficulties presented themselves in full measure to the successive generations of engineers who planned to bridge the river Derwent, at a place near its mouth where it is almost 4 000 ft wide, with a view to connect Hobart, the capital of Tasmania, with its suburbs and generally with the East coast of the island. These plans remained a dream for almost a century, and only then a scheme was evolved that would not only overcome the technical difficulties but — and this is a further important consideration — would also be within the financial reach of a smallish community, the population of Tasmania being about 240 000, of whom one quarter live in the capital.

The first reaction of the modern engineer to such a problem would probably take the form of a sketch of a suspension bridge. The cost of such a design would, however, have been prohibitive, not only because the solid rock was in places no less than 200 ft below the water level, but also on account of the long ramps that would have been necessary to give a headroom of 150 ft for sea-going ships.

A poor alternative to such a design is a pontoon bridge, but here

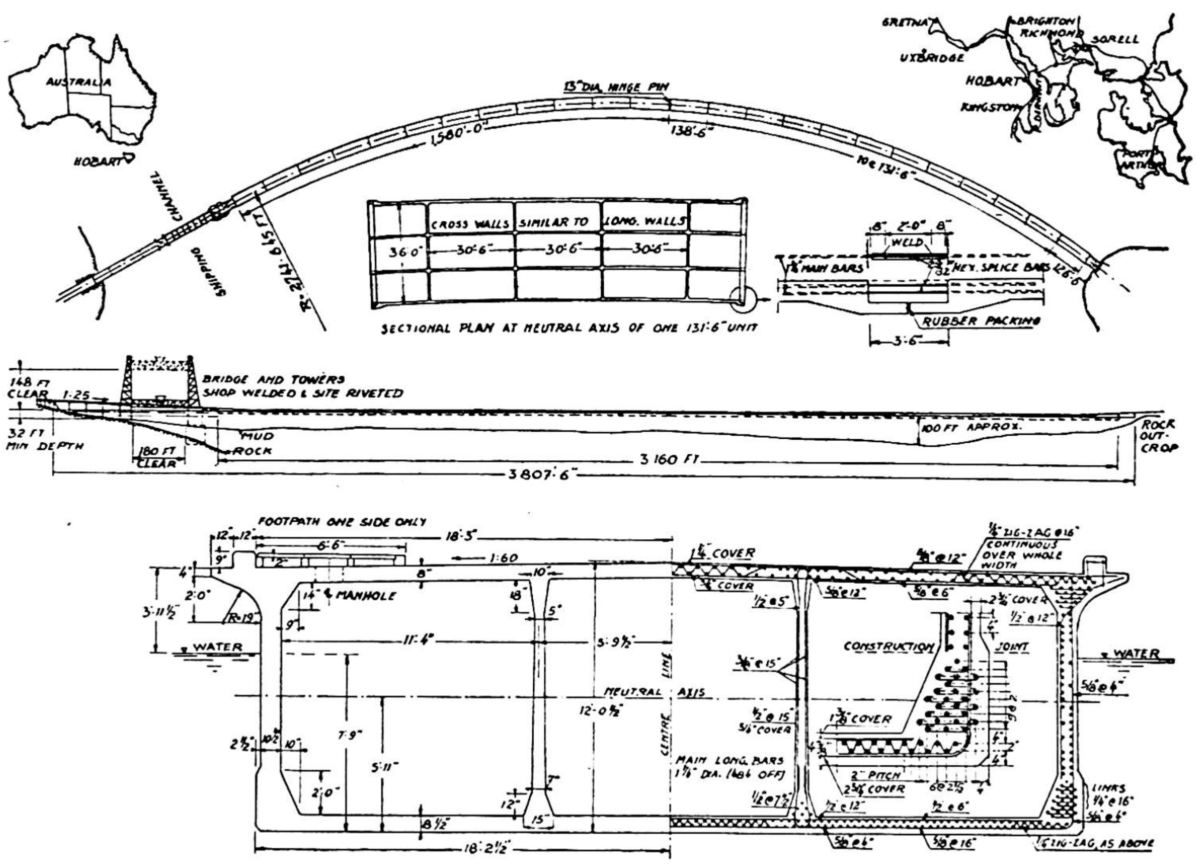

Fig. 1. Location, general arrangement and details of the brigde over the river Derwent.

again the anchoring of the pontoons and especially of the portion to be floated out for shipping purposes would have offered formidable, and, in view of the storms prevailing at some seasons of the year, perhaps insurmountable difficulties. The idea was therefore put forward to build the whole bridge in the form of one huge pontoon, with a lift bridge of appropriate dimensions at one end. If such a pontoon, of about 3 000 ft length, were to have been designed as one straight beam, spanning from shore to shore and resisting the horizontal pressure of wind, waves, currents, and tides, it would have required a width of anything between 200 and 300 ft, wholly unnecessary even for the heaviest traffic, and if built in reinforced concrete it would even then have been impossible to guarantee continued watertightness of the tension zone; the cost of such a structure would have been enormous.

It was therefore imperative to adopt a design that would ensure predominantly compressive stresses and the final answer was found in a huge horizontal floating arch. In this way the width could be reduced to reasonable dimensions, just sufficient to accommodate the required roadway of 30 ft width with a footpath of 6 ft on one side.

Figure 1 shows the general lay-out of this unique bridge and its main dimensions. A few short approach spans next to the Western shore are followed by the lift bridge which gives 148 ft headroom for a clear width of 180 ft at a minimum depth of water of 32 ft. The towers are about 180 ft high to centres of sheaves, the bridge has a span of 204 ft. The members of the towers as well as those of the bridge are of shop-welded design,

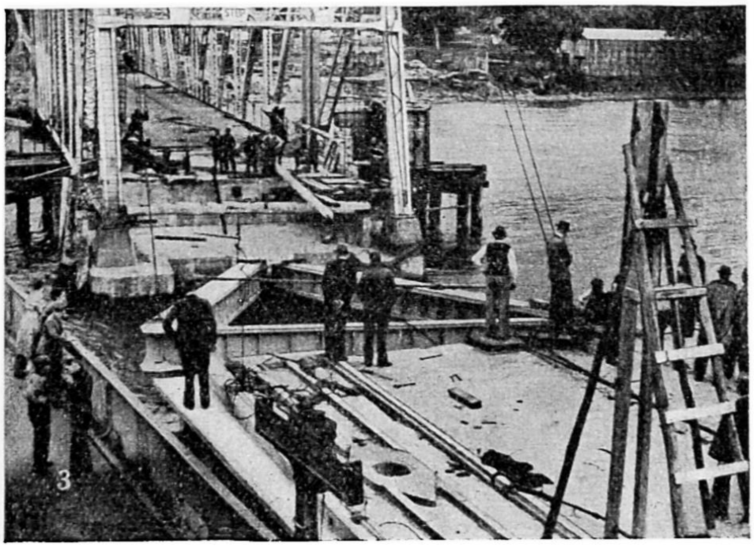

Fig. 2. View of the three-leg link of welded plate girder design.

with riveted connections at the nodes. The tower next to the shore rests on four reinforced concrete cylinders of 9 ft and 7 ft diameter respectively; the solid ground is here only 30 to 40 ft below the water line but falls rapidly away. The other tower stands on a mass concrete pier of 130 ft depth, with a base of 65 ft $\times$ 42.5 ft and a total weight of 18 000 tons.

This pier supports not only the tower of the lift bridge, but acts also as abutment for the floating arch. The latter is, however, not directly connected to it, as allowance had to be made for a normal tidal range of $\pm$ 3′ — 0″, a value that in extreme conditions may rise to $\pm$ 4′ — 6″. The necessary flexibility has been achieved by interposing a ramp of 60 ft length between arch and abutment, which is capable of following the rise and fall of the tide but does not transmit the thrust of the arch. The latter is taken up by a triangular linking arrangement underneath the ramp; the three legs of this link are of welded plate girder design (fig. 2). It is connected to the abutment by means of a single pin of 13″ diameter, weighing about 1.0 ton, and by two smaller pins to the end of the arch. A similar connection is provided at the other end of the bridge. Fortunately,

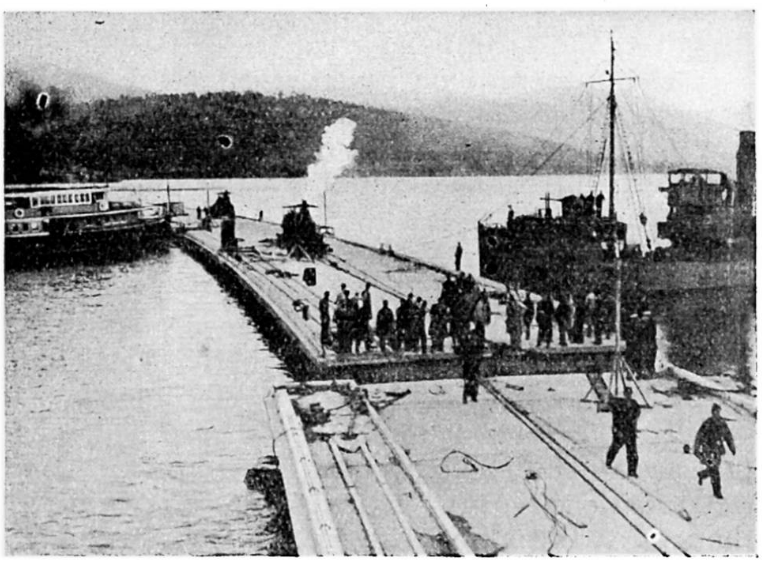

Fig. 3. Joining of the two halves at he centre.

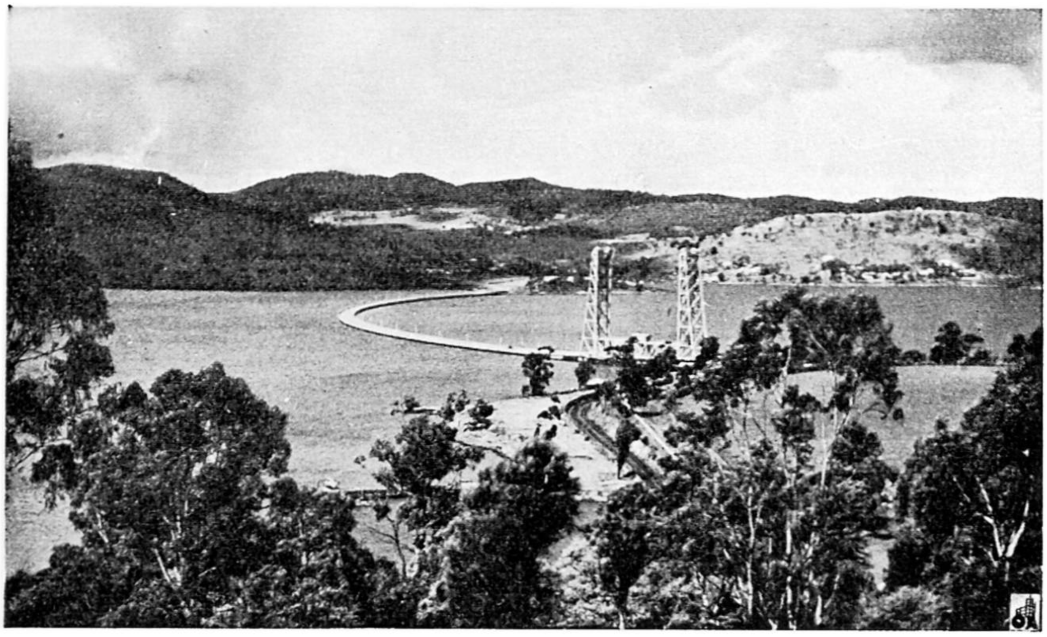

Fig. 4. View of the completed bridge.

the rock here comes to the surface and the anchorage of the arch offered no difficulties.

The floating portion is undoubtedly the most interesting and outstanding part of this bridge. It is in the form of a three-pinned arch of 2 740 ft radius, 3 160 ft length, and 443 ft ' rise '. The dimensions of the cross-section and details of the reinforcement are shown in figure 1, as is also a sectional plan of one of the 24 sections of which the arch was built; this shows the subdivision into cells by means of cross walls and longitudinal walls. These sections, of 131′ — 6″ length each, were built on land and their ends temporarily sealed so that they would float when launched. They were then temporarily bolted together, with rubber packings between adjacent ends so that the sealing walls could be removed. Suitable recesses had been provided at the ends into which the 484 longitudinal reinforcing bars of 1 1/4″ diameter projected and where they could be jointed by means of welding (see detail fig. 1). The recesses were then filled with concrete, so that by them two sections formed one monolithic unit of twice the length of the sections.

This process continued until all twelve sections of a half-arch had been moulded into one huge monolithic pontoon of 1 580 ft length with a weight of about 12 000 tons, that is 24 000 tons for the whole length of the arch; this figure includes 3 100 tons of steel reinforcement. It is interesting to compare the dimensions of this pontoon with the well known floating units of the Mulberry harbour. In cross-section the latter are much more impressive, as the largest of them had a width of 56 ft and a height of 60 ft. They were, however, ' only ' 204 ft long and had a displacement of no more than half that of the pontoon here described, namely 6 044 tons as compared with 12 000 tons.

The work so far described proceeded in a protected spot a few miles upstream. The structural and the launching difficulties that were encountered with this unprecedented design were by no means small and more than once the sceptics were on the point of being proved right; it took five months to get the first 1 000 ton section into its element. The lessons were, however, soon learnt, and this time was later cut to only 20 days per section of 131′ — 6″ length.

After both halves had been completed they were towed to the site on two consecutive days and temporarily moored there, and the following day saw the delicate operation of assembling them in their final position and attaching them to each other and to the abutments. Figure 2 shows the arch approaching one of the abutments and gives at the same time a view of the triangulated linking arrangement previously described. In figure 3 the two halves are about to be joined at the centre, and figure 4 is a view of the completed bridge. The assembly on the site took place on the 23rd of October, 1943, and the bridge was officially opened for traffic on the 1st of January, 1944.

The author, who was not himself connected with the design of this bridge, is of the opinion that it represents an outstanding example of the art of the bridge builder, an example, moreover, where the designer has freed himself completely from all tradition and prejudice, has studied the particular problems right down to their roots, and has arrived at a unique and wholly unprecedented solution which deserves a foremost place amongst examples of long span reinforced concrete bridges.

The design is due to Mr. A. W. Knight, Chief Engineer of the Public Works Department, Hobart, Tasmania. The author is indebted to this

Fig. 5. Other view of the completed bridge, with lift bridge in the foreground.

department and to the Agent General for Tasmania in London, for their assistance in the preparation of this paper.

Résumé

Ce mémoire décrit une construction originale en béton armé sous la forme d'un pont flottant de 960 mètres de longueur et d'un rayon de 834 mètres, ce pont, d'une largeur de 11 mètres (chaussée de $9^{m}10$ et trottoir de $1^{m}90$), traverse le fleuve Derwent, en Tasmanie. L'auteur indique les raisons qui ont motivé ce choix et décrit quelques détails constructifs (y compris le pont levant partiellement soudé pour la passe navigable); il donne également les précautions prises pour le montage.

Zusammenfassung

Die Arbeit beschreibt einen einzig dastehenden Eisenbetonbau in der Form eines schwimmenden wagerechten Bogens von 960 m Länge und einem Halbmesser von 834 m, der zur Ueberführung einer 9,10 m breiten Strasse nebst einem 1,90 m breiten Fussweg über den Derwent in Tasmanien dient. Die Gründe, die zur Wahl dieses ungewöhnlichen Systems geführt haben, werden angegeben und einige Konstruktionseinzelheiten beschrieben (einschliesslich der teilweise geschweissten Hubbrücke für die Schiffahrt), ebenso auch die Massnahmen für den Zusammenbau.

Summary

The paper describes a unique reinforced concrete structure in the form of a floating horizontal arch of 3 160 ft developed length, with a radius of 2 740 ft, which carries a 30 ft roadway and a footpath of 6′ — 6″ width across the river Derwent in Tasmania. The reasons for the adoption of this unusual design are stated, and some structural details (including the partly welded lift bridge for shipping) are described, as also the assembly procedure.