# Recent highway bridge practice in Great Britain

# RECENT HIGHWAY BRIDGE PRACTICE IN GREAT BRITAIN.

## NEUERE STRASSENBRÜCKEN IN GROSSBRITANNIEN.

## QUELQUES PONTS-ROUTES CONSTRUITS RÉCEMMENT EN GRANDE-BRETAGNE.

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During the last ten years nearly five thousand highway bridges have been constructed or widened in Great Britain, mainly by local authorities with financial assistance from and in consultation with the Ministry of Transport. With very few exceptions these bridges have been arranged to carry the Ministry's Standard Loading, originally introduced in 1922, of which the Equivalent Loading Curve, described by the author in a paper presented before the Paris Congress in 1932, is a development. It is intended in the present paper to indicate very briefly the general trends of British engineering practice as exemplified in these bridges and to describe in a few words some of the more interesting and typical examples.

The subject may be conveniently considered under the following three headings:

1. New bridgework in steel.
2. New bridgework in reinforced concrete.
3. Widenings and strengthenings of existing bridges.

### 1. New bridgework in steel.

The normal form of construction for very small span steel bridges is a deck of joists embedded in a solid slab of concrete, or of steel troughing filled with concrete. For slightly larger spans, including those over two-track railways, built-up girders spaced about 5 feet centres and jack arches are the most common type. The jack arches are now often constructed of precast concrete.

For larger spans the deck type of continuous plate girder and suspended span bridge has become increasingly common of late years. Such bridges, the decks of which are usually of rolled steel joists in concrete or reinforced concrete slabs, have been built at East Linton in Scotland, Sleights in Yorkshire and elsewhere. The bridge at East Linton, which is on the Great North Road between Berwick and Edinburgh, is illustrated in Fig. 1. The girders are spaced at 10′—2″ centres and the three spans are of 70, 106 and 70 feet. The largest example is the recently authorised cantilever and suspended span bridge over the Thames at Wandsworth in London. A start will shortly be made on this structure, which will have three spans of length 165, 284 and 165 feet; its width will be 60 feet 6 inches.

Truss bridges, apart from opening structures, have been comparatively few.

*) Optional paper read at the 2nd Congress of the I. A. B. St. E. in Berlin, October 1936.

Three steel portal frame bridges of comparatively large size have recently been projected. Two of these, of which one has been completed and the other is under construction, are in the county of Oxfordshire and are over railways. The larger is at Wolvercot and carries the Oxford Bypass over

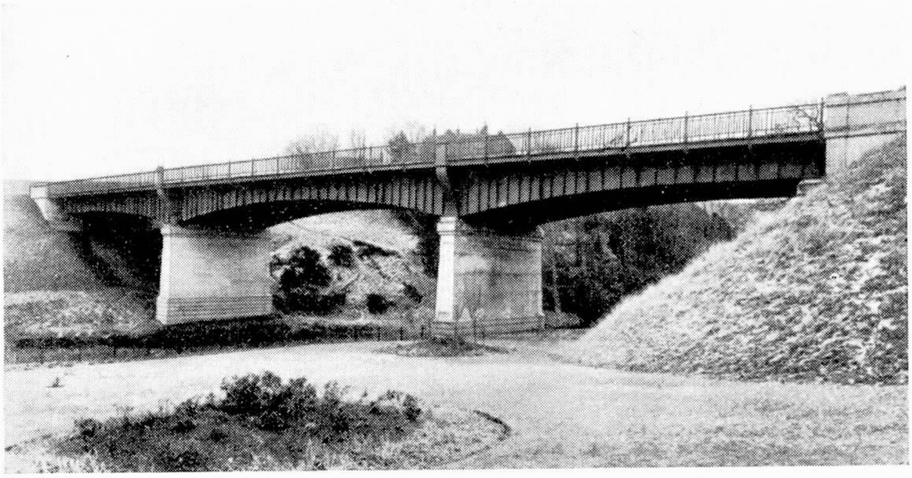

Fig. 1.
Brücke in East Linton zwischen Berwick und Edinburgh.
Pont à East Linton entre Berwick et Edinbourg.
Bridge at East Linton between Berwick and Edinburgh.

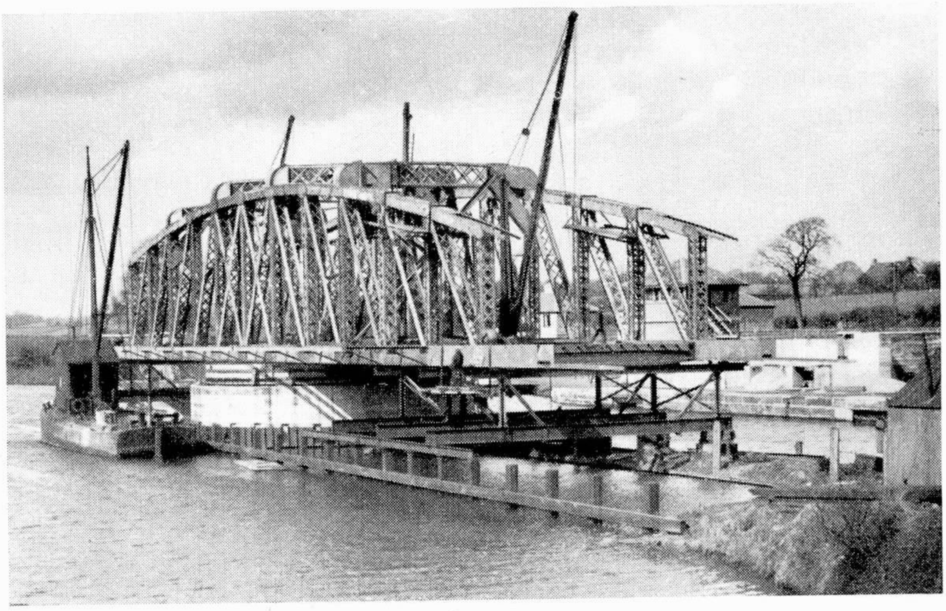

Fig. 2.
Drehbrücke bei Acton in Cheshire.
Pont tournant à Acton (Cheshire).
Acton Swing Bridge, Cheshire.

the Great Western Railway. It has a considerable angle of skew and consists of 7 built-up steel frames having a skew clear span of 86 ft. 10 ins., the remainder of the structure, including the wing walls, being of steelwork embedded in concrete. The parapets are of stone. The third bridge is intended to replace a suspension bridge crossing the River Avon at Bath, and it is proposed to invite tenders on two alternative schemes, one for a welded and one for a riveted structure. The span will be 157 feet.

Another deck bridge of some interest is the all welded structure carrying the northern approach to the new Middlesbrough lift bridge over the London and North Eastern Railway. This has a width of 55′ 6″ and spans of 28, 48, 64, 48, 28 ft. It is a combination of the portal frame and suspended span types.

A number of opening bridges have been erected during the last few years. Several large plate girder swing bridges have been built to carry

Fig. 3.
Newport - Brücke über den Tees in Middlesbrough.
Pont de Newport sur le Tees à Middlesbrough.
Newport Bridge over the Tees at Middlesbrough.

main roads over the Caledonian and Crinan Canals in Scotland, the largest having a clear opening of 52′ 6″. The Boothferry Bridge was constructed in 1929 as a link between the highways of South and East Yorkshire. It consists of one double swing span and five fixed spans. The swing spans have lengths of 120 feet and 53 feet while the total length of the bridge is 698 feet.

A number of swing bridges of the pontoon type have been erected over the Weaver Navigation in Cheshire. The largest of these, that at Acton, is shown in Fig. 2. The two spans are each 82 feet on the skew. The bridge is situated near the brine pumping area near Northwich. The main weight of the structure rests on the pontoon and necessary adjustments due to settlement of the foundation can easily be made.

The most recently constructed swing bridge is that at Kincardine-on-Forth, in Scotland. It has a double swing span of 150 feet and 150 feet clear openings, a total length including approaches of 2,876 feet and a width between parapets of 40 feet, including a carriageway of 30 feet and two footways each of 5 feet.

Scherzer rolling lift bridges have been built over the Dee at Queensferry (a double leaf structure with an opening of 134 feet and a total length of 400 feet) at Grimsby, Weymouth, Hull and elsewhere. Bascule bridges have been few in number but that at Yarmouth and the Werkspoor bascule bridge at Lambhill near Glasgow may be mentioned.

Vertical lift bridges have been erected in some cases where space is limited and this type is particularly applicable. The only large example is the Newport Bridge over the Tees at Middlesbrough (Fig. 3), which has a

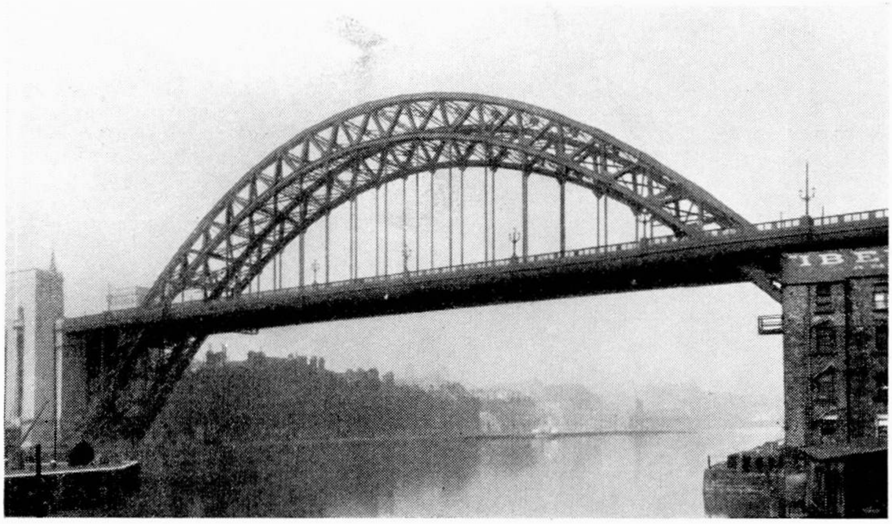

Fig. 4.
Brücke über den Tyne in Newcastle — Pont sur le Tyne à Newcastle — Tyne Bridge at Newcastle.

span of 250 feet, a headroom over the river of 120 feet and towers 170 feet high, and a roadway width of 56 feet. The cost of this bridge, including land and approaches, was about £ 500 000.

A steel bowstring bridge is now under construction at Ruswarp in Yorkshire which will have a span of 176 feet.

Steel arches have been erected in a number of instances, outstanding examples being the Tyne Bridge at Newcastle and the Sunderland-Wearmouth Bridge, both of which are of the half through braced type. The former (Fig. 4) is a two pinned arch of 531 feet span with approach plate girder viaducts having spans varying from 99 feet to 153 feet. There is a clear headway of 84 feet over high water of ordinary spring tides, a total length of 1,844 feet, a 38 foot carriageway and two 9 foot footways. The total cost of the bridge, which carries the Great North Road over the River Tyne, was £ 1 299 000 including land and property. The latter bridge crosses the River Wear at Sunderland. It was originally designed as a two pinned arch, but the discovery of old mine workings below the foundations made it desirable to construct it with three hinges. There is one 375 foot span with a rise of 105 feet and the bridge has a 48 foot carriageway and two 15′ 9″ footways. The total cost was £ 272 000.

Another notable steel bridge is that over the River Thames at Lambeth, which has five spans ranging from 165 feet to 125 feet. The arches, which had temporary crown hinges during construction, are two hinged and spandrel braced. There is a 36 foot carriageway and two 12 foot footways.

New suspension bridges are represented only by that over the River Thames now under construction at Chelsea. This will have a main span of 352 feet and a total width of 64 feet, including a 40 foot carriageway and two 12 feet footways. Suggestions have, however, been put forward for

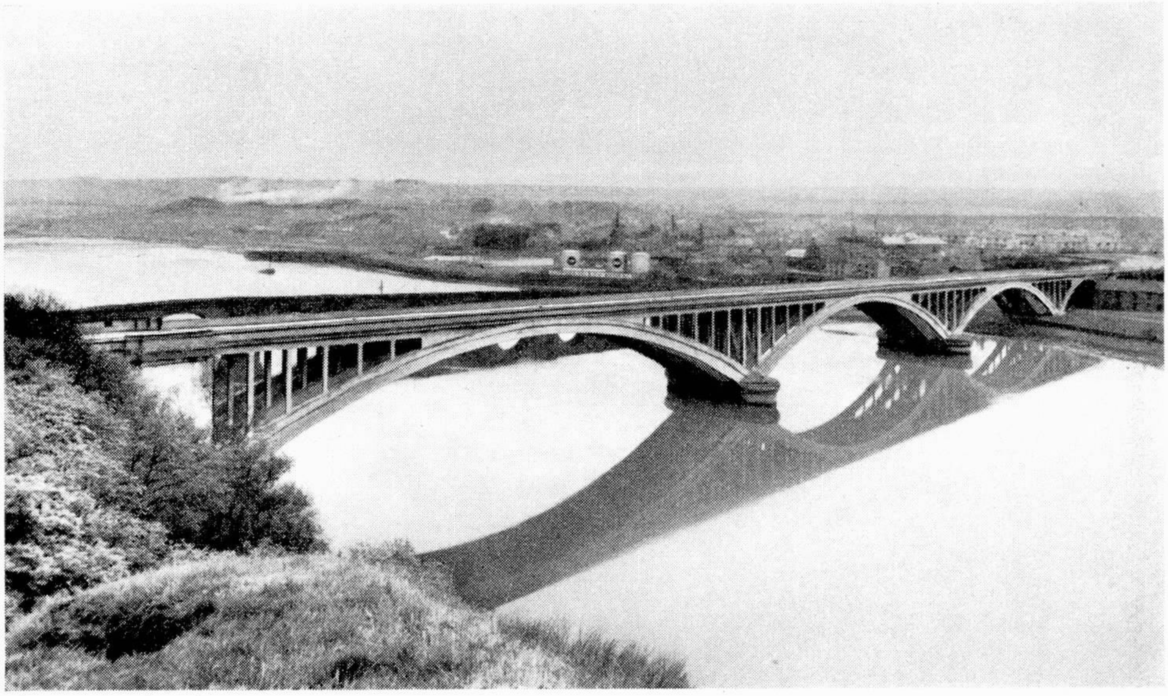

Fig. 5.
Brücke über den Tweed bei Berwick — Pont sur le Tweed à Berwick — Tweed Bridge at Berwick.

bridges over the Forth with a span of 3000 feet, the Humber with a span of 4500 feet and the Severn with a span of 1400 feet.

The decks of the larger steel bridges usually consist of troughing filled with concrete, rolled steel joists in concrete, a reinforced concrete slab or, in a few cases, buckled or dished plates carrying a concrete slab. Surfacing is usually asphalt or wood blocks. Timber floors were used for the Queensferry and Grimsby opening bridges.

## 2. New bridgework in reinforced concrete.

Small bridges up to 20 feet span (or more in special circumstances) are generally built with plain slab decks and often with abutments designed as strutted apart by the deck. Somewhat larger bridges have beam and slab decks with beams usually about 6 feet apart. Where reinforced concrete bridges have been constructed over railways precast beams have often been employed, a common type consisting of cored out beams placed side by side and arranged to have a vertical groove with roughened sides between each pair of beams. Concrete is poured into these grooves when the beams are in position and locks them together so that the deck is as far as possible monolithic.

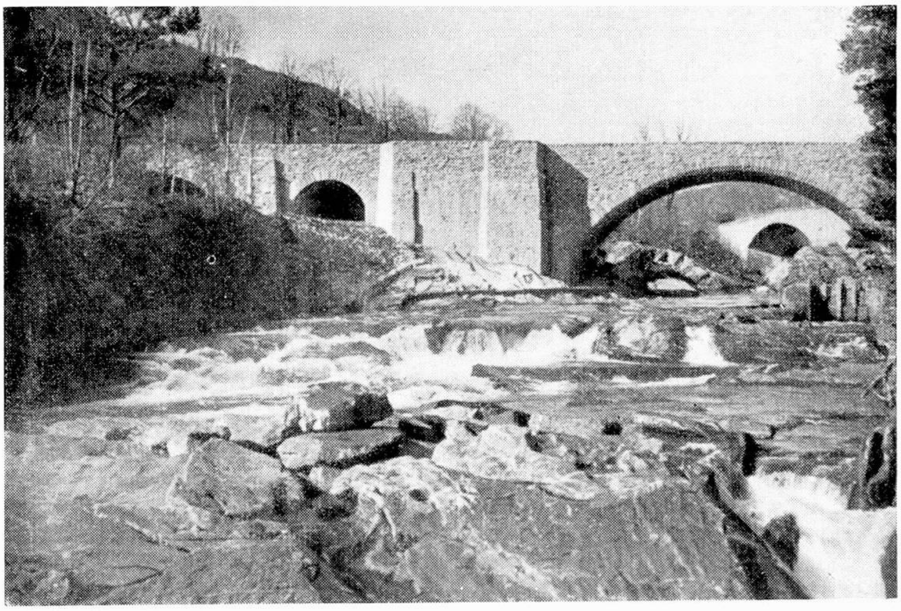

Fig. 6. Invermoriston.

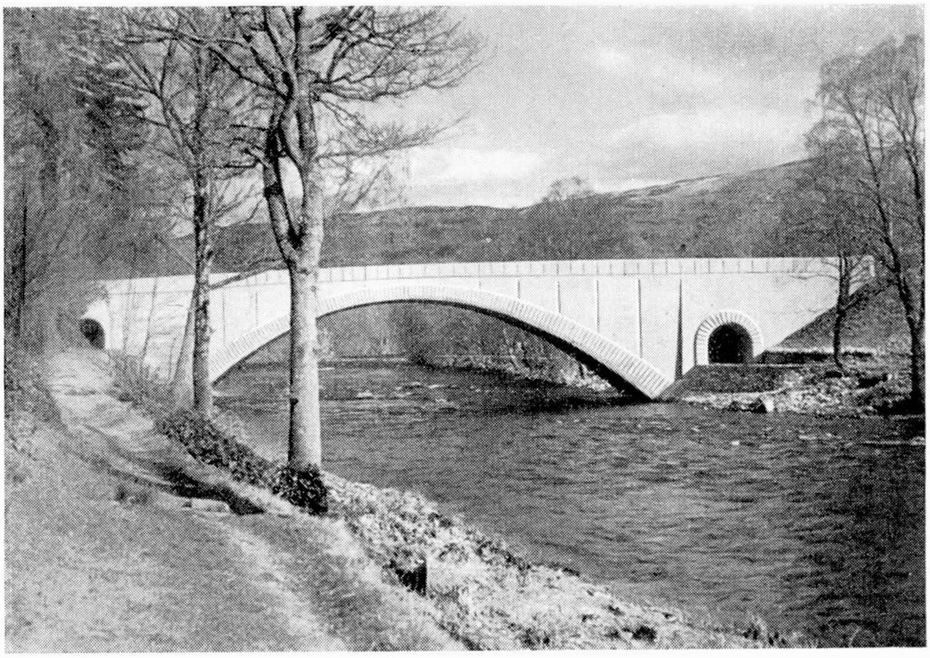

Fig. 7.
Brücke in Invergarry (Schottland). — Pont à Invergarry (Ecosse).
Bridge at Invergarry (Scotland).

Box culverts are employed where conditions are suitable, and a type has recently been evolved for use where foundations are particularly bad (as in the case of marsh dykes). Here the deck is extended beyond the side walls on each side so as to rest on the adjoining banks (the foundations of which are usually more stable than the bed of the dyke) and therefore to relieve the dyke bed from load.

A number of viaducts have been constructed over land subject to floods, over ravines and across railways. In order to avoid the unsatisfactory ap-

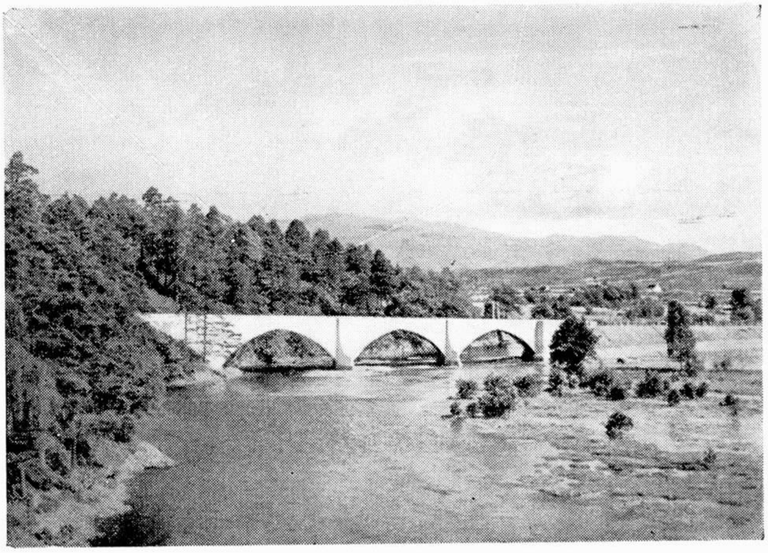

Fig. 8.
Brücke in Oich (Schottland) — Pont à Oich (Ecosse) — Bridge at Oich (Scotland).

Fig. 9.
Brücke in Abingdon, Grafschaft Berkshire — Pont à Abingdon, Berkshire — Abingdon Bridge in Berkshire.

pearance of a forest of supporting posts (particularly unfortunate where the road is of great width) it is becoming a common practice to support the deck on a smaller number of suitably grouped mass concrete piers. The new viaduct which will carry the Western Avenue over the Colne Valley in Middlesex and Bucks will be a case in point. This, like many other modern viaducts, is designed as a continuous beam and suspended span structure.

Portal frames are common, the largest being at Wisbech in Cambridgeshire, which has a span of 92 feet and a width of 45 feet. Another interesting example is a slab portal frame on the Bexley Heath Bypass which has a skew span of 63 feet.

The most remarkable continuous girder bridge is perhaps the King George V Bridge at Glasgow. This bridge, the design of which was particularly difficult owing to conditions of gradient and headroom over the River Clyde, has three spans of 110, 146 and 110 feet and a width of 80 feet. The superstructure rests on cast steel rollers.

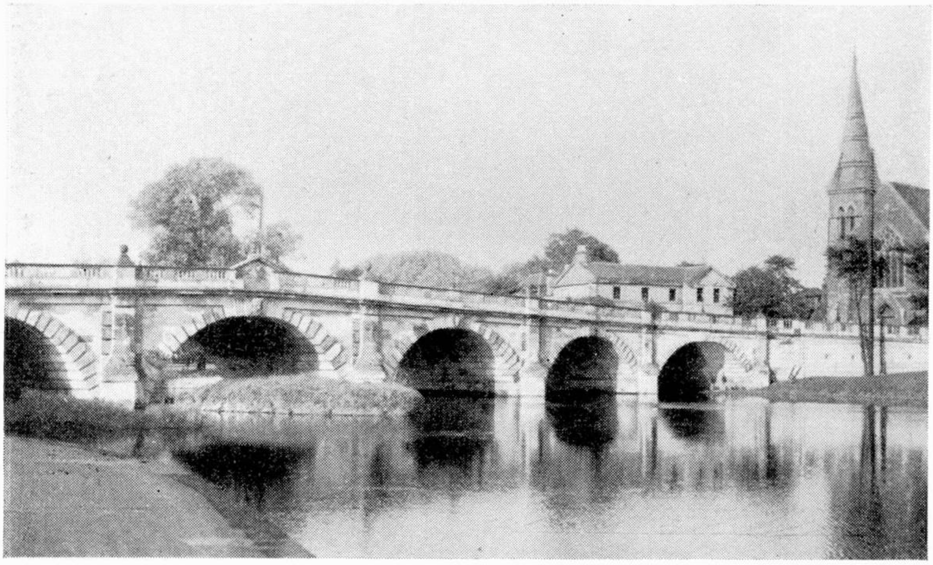

Fig. 10.
Die „Englische" Brücke in Shrewsbury, Grafschaft Shropshire — Pont „Anglais" à Shrewsbury (Shropshire) — English Bridge, Shrewsbury (Shropshire).

Truss bridges have not been numerous. Among the more interesting are that at Montrose in Scotland which has a central span of 216 feet, (including a short suspended span) and two approach spans each of 108 feet; and a structure having two 96 foot spans somewhat of Vierendeel type over the River Findhorn, also in Scotland. Both these bridges have bush-hammered surfaces.

A few bowstring bridges have been built with spans in the neighbourhood of 100 feet.

Arch bridges are numerous and are of almost every style and type. Nearly all are fixed though there are a few two and three hinged examples, and temporary hinges have been employed during the erection of others.

The largest reinforced concrete arched bridge in Great Britain is that at Berwick which is a successful example of a bridge carrying a roadway rising from one side of the crossing to the other and having a series of arches of increasing span (Fig. 5). The four main spans from south to north measure 167 feet, 248 feet, 285 feet and 361 feet; the total length of the bridge is 1405 feet and it has a width of 46 feet. It carries the Great North

Road over the River Tweed. The main ribs are cored and the parapet is of dressed stone.

The three bridges over the Thames in the Western suburbs of London present interesting contrasts in architectural treatment; all have three spans and are ribbed, with intrados vaults. Chiswick and Hampton Court are fixed arches while Twickenham has three hinges. Chiswick is faced with stone, Hampton Court with brick dressed with stone while Twickenham has a surface of bush-hammered concrete and a bronze parapet.

The new Waterloo Bridge in London will be of reinforced concrete faced with stone and will have five equal spans of about 230 feet and a total width of 80 feet.

Other notable arches have been built in Scotland at Dunglass, where there is an open spandrel fixed structure of 157 feet span; and Dunfermline, where has been built a bridge of somewhat similar type but of 185 feet span.

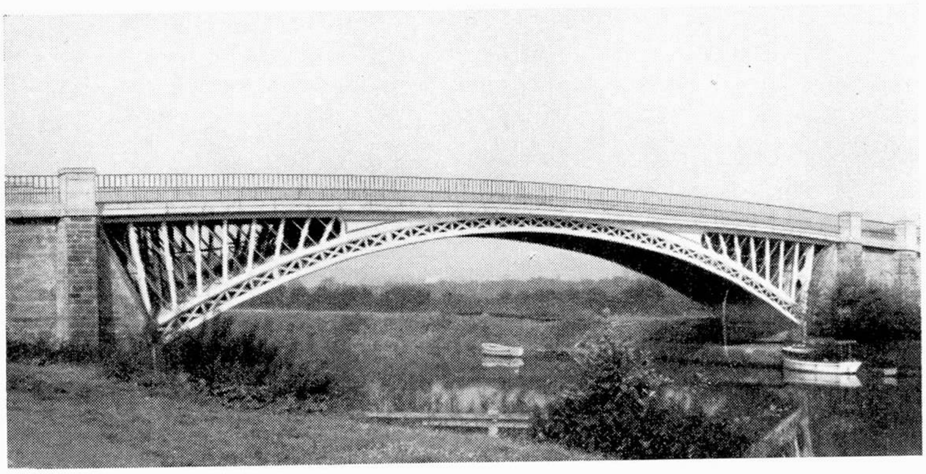

Fig. 11.
Holt Fleet Brücke bei Ombersley (Worcestershire) — Pont du Holt Fleet à Ombersley (Worcestershire) — Holt Fleet Bridge, Ombersley (Worcestershire).

On the Inverness-Fort William Road there is a particularly interesting succession of bridges. Invermoriston (Fig. 6) is faced with local stone and has a number of spans, the largest of 73′ 6″. Invergarry (Fig. 7) with a single span of 111 feet, is bush-hammered throughout and is an open spandrel arch with false spandrel walls. Oich (Fig. 8) has three arch spans, the maximum having a length of 77 feet; the arches are ribbed and have three hinges, and the surface of the concrete was bush-hammered. Another recent bridge in the Scottish Highlands is that at Grantown-on-Spey. This has a three hinged arch span of 240 feet and is of open spandrel construction; in this case, as in that of Invergarry, false spandrel walls were provided and the finish was of coloured concrete bush-hammered.

## 3. Strengthening and widenings of existing bridges.

In nearly every case where a bridge has been strengthened it has also been necessary to widen it, and to a somewhat less extent the reverse is true.

Ancient masonry or brick arch bridges have most commonly been widened, with the approval of the Ancient Monuments Department of the Office of Works, by taking down one face and re-erecting it on the new line, using the old material as far as possible. The extended arch vaults have often been constructed of reinforced concrete with the surface left comparatively rough so as not to contrast too strongly with the original materials of the bridge. In some cases, as in the old Richmond Bridge, Surrey, and the Countess Wear Bridge, Devon, the old structure was on gravel and it was thought advisable to carry down the foundations of the widened portion to a greater depth. In the former case it is proposed to consolidate chemically the gravel beneath the old foundations by the Joosten method; while in the latter the foundation gravel has been grouted and the arches themselves have been strengthened by grouting the gravel fill above them.

Fig. 9 shows the Abingdon Bridge in Berkshire over the Thames, where one section of an ancient many arched bridge has been successfully rebuilt and a modern 60 foot span reinforced concrete arch inserted. A somewhat different type of widening is exemplified at Shrewsbury, where the beautiful eighteenth century English Bridge was taken down and re-erected to a greater width and with a considerably reduced hump (Fig. 10).

A number of cast iron arch bridges exist in Great Britain. Most of these are about a century old and a number of them have been strengthened in reinforced concrete. The largest to undergo this treatment is that over the River Severn at Holt Fleet in Worcestershire (Fig. 11). This bridge was strengthened by encasing the ribs with reinforced concrete, constructing a continuous intrados vault and extrados vaults adjacent to the arch springings, while a new reinforced concrete deck of greater width than the old cast iron deck was erected on the old spandrel columns, which were also encased in reinforced concrete. Owing to the difficulty of lapping bars in confined spaces the reinforcing bars were suitably welded to each other and to the cast iron of the old structure. The span of this bridge is 150 feet.

The general tendency in highway bridge design, both steel and concrete during the last few years, has been in the direction of increased simplicity and economy; at the same time more attention has been paid to appearance. The proposal for a new bridge at Upton on Severn, is an example. The advice of the Office of Works has been for some years available to all those wishing to widen or reconstruct bridges of archaeological interest; more recently, designers of important bridges or those in surroundings of special beauty or historical interest have been asked by the Ministry of Transport to submit their schemes to the Royal Fine Art Commission.

## Summary.

The author refers to the 5000 highway bridges constructed and widened in Great Britain during the last 10 years and considers examples under the headings—

1. New bridge work in steel.
2. New bridge work in reinforced concrete.
3. Widening and strengthening of existing bridges.

Normal construction details are given for small, medium and large span bridges. Special types such as portal frames, moving, arch and suspended span, etc. are described.

The author deals with architectural and surface treatment of reinforced arch bridges. The preservation of existing elevation of ancient bridges is also considered.

## Zusammenfassung.

Der Autor bezieht sich auf die 5000 Straßenbrücken, die in den letzten zehn Jahren in Großbritannien erbaut oder erweitert wurden, und geht auf einige Beispiele unter folgenden Titeln näher ein:

1. Neue Brücken in Stahl.
2. Neue Brücken in Eisenbeton.
3. Erweiterung und Verstärkung von bestehenden Brücken.

Es werden normale Konstruktionseinzelheiten für Brücken mit kleinen, mittleren und großen Spannweiten gegeben und besondere Brückentypen beschrieben, wie z. B. Portalrahmenbrücken, bewegliche Brücken, Bogen- und Hängebrücken etc.

Der Autor bespricht architektonische Fragen und solche der Oberflächenbehandlung, die sich auf Eisenbeton-Bogenbrücken beziehen. Auch verweist der Verfasser auf die Erhaltung der bestehenden Form alter Brücken.

## Résumé.

L'auteur se réfère aux 5000 ponts-route qui, au cours de ces 10 dernières années, ont été construits ou rénovés en Grande Bretagne. Il cite quelques exemples groupés suivant le schéma suivant.

1. Nouveaux ponts métalliques.
2. Nouveaux ponts de béton armé.
3. Elargissement et renforcement de ponts anciens.

Description de quelques particularités de ponts de petite, moyenne et grande portée ainsi que de certains types de ponts tels que: ponts en cadre, pont mobiles, ponts en arc, ponts suspendus, etc.

L'auteur expose certaines questions architectoniques et certaines questions du traitement des surfaces relatives aux ponts de béton armé. Il conseille le respect des formes existantes.

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