King George VI-Bridge at Aberdeen

Autor(en): **Spicer, C.W.J.**

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Le pont King George VI à Aberdeen

King George VI-Brücke in Aberdeen

King George VI-Bridge at Aberdeen

C. W. J. SPICER
M. I. Struct. E., London
Chief Engineer – Considere Constructions, Ltd.

It was necessary to provide additional cross-river traffic accommodation over the River Dee to the South, and this became more urgent by the development of the housing estate at Kincorth. A site for the new Bridge was chosen to form a continuation of Allenvale Road on the North side of the River. This site is free from obstruction by neighbouring buildings and presents an unobstructed view of the proposed bridge for a considerable distance both upstream and downstream along the River.

An essential requirement was made that the Bridge must be faced with granite. All buildings of a monumental character in Aberdeen are constructed in granite, for which the City is famed. There are several quarries in the immediate vicinity, including one 400 ft deep within the City boundaries.

In the case of a bridge designed to carry the Ministry of Transport's Standard Loading, however, an all-granite construction would be very heavy and costly, and with the proposed rise-span ratios to the arches it would not have been possible to design a bridge wholly of granite. The City Engineer decided that reinforced concrete should be the principal structural material for the arches and the roadway deck but that all exposed surfaces, with the exception of the underside of the arches, should be faced with granite. The parapets were required to be wholly of granite.

The City Engineer, Mr. T. F. Henderson, M. C., M. I. C. E., prepared the general plan of the bridge, establishing the spans of the arches, width of carriageways and footpaths and the longitudinal gradients. The City Council appointed as Consulting Engineers, Messrs. Considere Constructions, Ltd., of Westminster, and as Consulting Architect, Mr. (now Sir) Frank Mears, P. P. R. S. A., F. R. I. B. A., of Edinburgh. Collaboration between Engineer and Architect was thus ensured at the commencement of the design, which is so desirable and is recommended. for all important work, especially where masonry forms the visible material in the structure.

The spans selected by the City Engineer were 100 feet, for each side span and 120 feet for the centre span, with wing walls on both sides of the river and two long retaining walls on the northern bank which were necessary so that the level of the road to Riverside Drive could be raised where it intersects with the approaches to the new bridge.

The width of the bridge between parapets is 75 feet, accommodating two footpaths 15 ft wide, two carriageways 20 feet wide, and a central island 5 feet wide dividing the carriageways.

The Architect, for aesthetic reasons, expressed a strong preference for a semi-elliptical curve to the soffits of the arches, and this was agreed to by the Consulting Engineers, although such a curve is not the best from the point of view of economy in materials. However, the bridge, by modern standards, is not large, and the extra concrete and reinforcement required to resist the greater permanent bending moments due to the elliptical shape was not considered to be extravagant in cost. The success of a bridge is usually judged by its architectural merit in association with its setting, and since the opening of the bridge to traffic in 1941, King George VI Bridge has received unqualified praise in this respect.

With the moderate spans as stated above and adequate rises to the reinforced concrete arches, no special provision was thought to be necessary to neutralise bending moments due to shrinkage of the concrete in setting. Therefore, hydraulic jacks at the crown of the arches, or temporary hinges at the springings and crowns were not contemplated. In fact, if hydraulic jacks were used, it would probably have been necessary to omit temporarily some or all of the granite voussoirs until after the arch vaults had been constructed and opened by the jacks. It was considered that the most satisfactory method of securing the voussoirs to the concrete was to lay them in position on the arch staging with rebates to receive the concrete, and with bronze cramps built in the joints and extending into the concrete vault. The concrete could then be deposited after the whole of the granite voussoirs were in place. Six transverse strips of concrete vault to each arch were specified to be temporarily omitted and the voussoir stones opposite these gaps laid with dry joints. These temporary gaps were to be concreted after the main concrete had been in place for about five weeks, to permit the initial shrinkage to occur. The joints in the voussoirs were then to be run with grout and pointed at the same time.

Two test bores were sunk, one in the position of the future North Abutment and the second midway between the South Abutment and the River Pier. Sand and gravel strata alternating with thin layers of boulders were present at the levels to which it was proposed to found the Abutments and River Piers. The nature of the material removed from the bores, however, was not altogether satisfactory, and it was agreed that provision should be made in the Contract documents and drawings for reinforced concrete piles and to postpone a decision as to their adoption until the excavations to the foundations had been carried down to their approved level.

The River Piers and Abutments are of mass concrete construction, the concrete being mixed in the proportions of one part of Portland Cement to three parts of sand and six parts of stones. The stones forming the coarse aggregate in the concrete were of granite, graded from 3 inches downwards and « plums » or displacer stones, not exceeding two cubic feet in volume, were permitted in the hearting to the Piers and Abutments.

The River Piers are 13 feet 6 inches wide at springing level with a spread base 24 ft wide below the river bed having its lower surface inclined to an angle at right angles to the resultant of all dead loads and thrusts from the two arches. This width was proportioned to limit the pressure on the ground under dead load alone to 2.3 tons per sq. ft, which was uniform throughout the entire area of the base. With the most severe arrangement of live loading on the central arch, the maximum pressure on the ground increases to 4.2 tons per sq. ft.

The Abutments are of similar design, but it was not possible to achieve uniform pressure on the ground for dead load only. This pressure varied from 3.3 tons per sq. ft at the outer edge to 1.1 tons per sq. ft at the river edge of the Abutment. The width of the base was 33 ft and the bottom was inclined so as to be normal to the resultant of all dead loads. When the live load covers the side arch and the Abutment, the maximum ground pressure increases to 4 tons per sq. ft.

In the event of these pressures exceeding the estimated safe ground pressure at foundation level, a piling lay-out was drawn up. The piles were to be octagonal in section, 14 inches across the flats and about 30 feet long, each reinforced with eight longitudinal bars and lateral ties in the form of a continuous helix. Under each River Pier, 82 piles were arranged in four rows, the outer rows battered 1 in 10, whilst the two inner rows were to be vertical. In each Abutment foundation 95 piles were to be evenly spaced in six rows. The two rows nearest the River being vertical, and in the remaining rows, the piles were to be driven to a batter of 1 in 6 1/2. The maximum load per pile was calculated to be 75 tons, assuming that the piles carry the whole weight from the bridge, including the weight of the Pier or Abutment. Some relief of this load was expected because of the resistance offered by the ground which received directly the weight of the mass concrete. The specified final penetration set for driving these piles was 10 blows to one inch with a hammer weighing 2 tons falling freely 4 feet.

The River Piers and Abutments are capped by reinforced concrete sleeper beams which receive and distribute the thrusts and reactions from the arches. The latter have wide bands on their underside as an architectural feature and also projecting ribs on their upper surface, which receive directly the concentrated loads from the columns and dwarf walls supporting the deck. Only the soffit of the bands are elliptical in shape, and the intermediate vaults, 17 ft 6 in wide, are carried through to the Piers and Abutments in approximately a segmental curve.

Calculations for the bending moments and thrusts in the arches were based on the assumption of perfect fixity at the springings and monolithic construction throughout the entire structure. The arch was treated as one unit for the full width including the projecting bands on the soffit. The curve of the mean fibre took the parabolic form represented by the expression :

$$y = f\,(g - 0.64\ m^2 - 0.36\ m^4)$$

where y = ordinate measured from the elastic centre at distance m.
f = rise of the mean fibre.

g = distance of elastic centre below crown.
m = horizontal distance from the crown in terms of the half span.

The overall depth of the centre arch vault and ribs at the crown is 3 feet 5 inches and it increases to 6 feet 8 inches at the springings. The corresponding depths for the side arches are slightly less than those stated for the centre arch.

The superstructure is of the usual slab and longitudinal beam arrangement with transverse expansion joints at each side of the River Piers and over the Abutments. Near the crown, the longitudinal beams become dwarf walls which merge into the wider arch ribs.

The concrete in the arch vaults and ribs at the crown sections was mixed in the proportions of one part of Portland Cement to one part of Sand and two parts of Coarse aggregate. In the remaining portions of the vaults and ribs and for all reinforced concrete work elsewhere, the proportions were one part of Portland Cement, 1 1/2 parts of Sand and 3 parts of Coarse aggregate.

The spandrel walls are faced with granite which was built in advance of the reinforced concrete backing. The latter was brought up course by course with the masonry. These walls were built after the major part of the reinforced concrete deck was constructed, so that the arches could carry the largest practical proportion of their dead load, and the longest possible period could elapse after the striking of the arch staging. This provision was designed to permit the arch vaults to shorten in length and settle at their crowns under the effects of initial shrinkage and creep, before the spandrel walls were built and thus avoid cracks in the masonry facework.

Generous accommodation has been allowed for large diameter pipe mains in the ducts under the footpaths. A narrower service duct is also provided below the central island, and is used for electric cables serving the lamp standards erected on the longitudinal centre line of the bridge.

All ducts are lined with asphalt which also covers the cambered top surface to the reinforced concrete deck slab to the carriageways. Selected dry filling was placed in these ducts and well packed around the pipes, cables, etc., and the footpaths were surfaced with Adamant paving slabs, 2 1/2 in thick, bedded in lime mortar. The central Island was covered with vegetable earth and sown with grass seed. It was intended to cover the carriageways with bituminous asphalt but in 1940 this material was not available and therefore tarred macadam was substituted.

The specification for the granite facing required that all dressings should conform to the samples previously prepared for the City Engineer and Consulting Architect, and stored at the Corporation Depot. All stones were of squared and coursed ashlar, bedded in Portland Cement mortar in the proportion of two parts of sand to one part of cement and pointed in lime mortar. Rock-faced dressing was specified for the granite facework of the Abutments, River Piers, Arch Voussoirs and spandrel walls with a chisel draughted margin of varying widths around each rock face. The parapet, including the capping, was finished on the outer face with a rough picked dressing and the inner face was fine axed. The stones were laid header and stretcher and varied in bed width from 12 inches to 18 inches in Piers and Abutments and from 7 inches to 13 inches in the spandrel walls. The Voussoirs were 16 inches on bed and varied from 30 inches to 48 inches deep. Every alternate voussoir stone was rebated at the back to form a seating on the reinforced concrete arch vault, and the remaining voussoirs had a dovetailed groove to permit the insertion of bronze cramps. These cramps were used liberally throughout the facework and dowels were introduced in the joints of the parapet. The cramps were 1 1/2 inches × 1/4 inch × 12 inches girth with ends turned down 1 1/2 inches, but larger cramps were adopted for the voussoirs.

Figures pages 398 and 399 give the general design of the Bridge.

The contract drawings, specification and bills of quantities were sent to experienced Contractors, on which they prepared their Tenders. After careful study and examination of the prices and suggested proposals for carrying out the work, the Contract was awarded to Messrs. W. J. Anderson, Ltd., of Aberdeen. The following gives the analysis of the prices and costs in the successful tender.

Description	Quantity	Average Rate	Cost	Per cent of Total
		s. d.	£	%
Sums to cover General Conditions			4 195	3.83
General Works			646	0.59
Cofferdams			12 000	10.96
Temporary Staging			7 000	6.39
Temporary Bridge			1 200	1.10
Excavations	7 967 cub. yd	6. 10.	2 728	2.49
Return filling to ditto	3 036 cub. yd	2. 0.	304	0.28
Reinforced Concrete Piles.				
Driven.	6 862 lin. ft	13. 3.	4 561	4.17
Cast.	11 583 lin. ft	7. 10.		
Mass Concrete Work	6 941 cub. yd	£ 1. 9. 5.	10 211	9.33
Reinforced Concrete Work	4 376 cub. yd	£ 1. 16. 5.	7 973	7.28
Shuttering	13 927 sq. yd	5. 7.	3 879	3.54
Reinforcement	410 tons	£ 17. 19. 5.	7 368	6.73
Bush Hammering to Arches	3 328 sq. yd	2. 0.	333	0.30
Expansion Joints	549 lin. ft	4. 3.	117	0.11
Granite Facing	19 043 cub. ft	£ 1. 11. 8.	30 136	27.53
Granite Parapets	945 lin. ft	£ 9. 10. 4.	8 994	8.21
Roads and Footpaths	3 744 sq. yd	19. 4.	3 618	3.30
Special Works. (Borings, tests, etc.)			4 223	3.86
	TOTAL FOR BRIDGE		£ 109 486	100 %
Riverside Drive, Retaining Walls			9 233	
	GRAND TOTAL		£ 118 719	

Mr. J. F. Carne, A. M. I. C. E., was appointed Resident Engineer and supervised the construction throughout in a most efficient manner.

The Contractors commenced work on the site in December 1937, and after the temporary offices, sheds, workshops, and hoardings were erected on both sides of the river, two electrically-operated Scotch derrick cranes, capable of lifting a maximum load of 5 tons and having jibs of 110 ft and

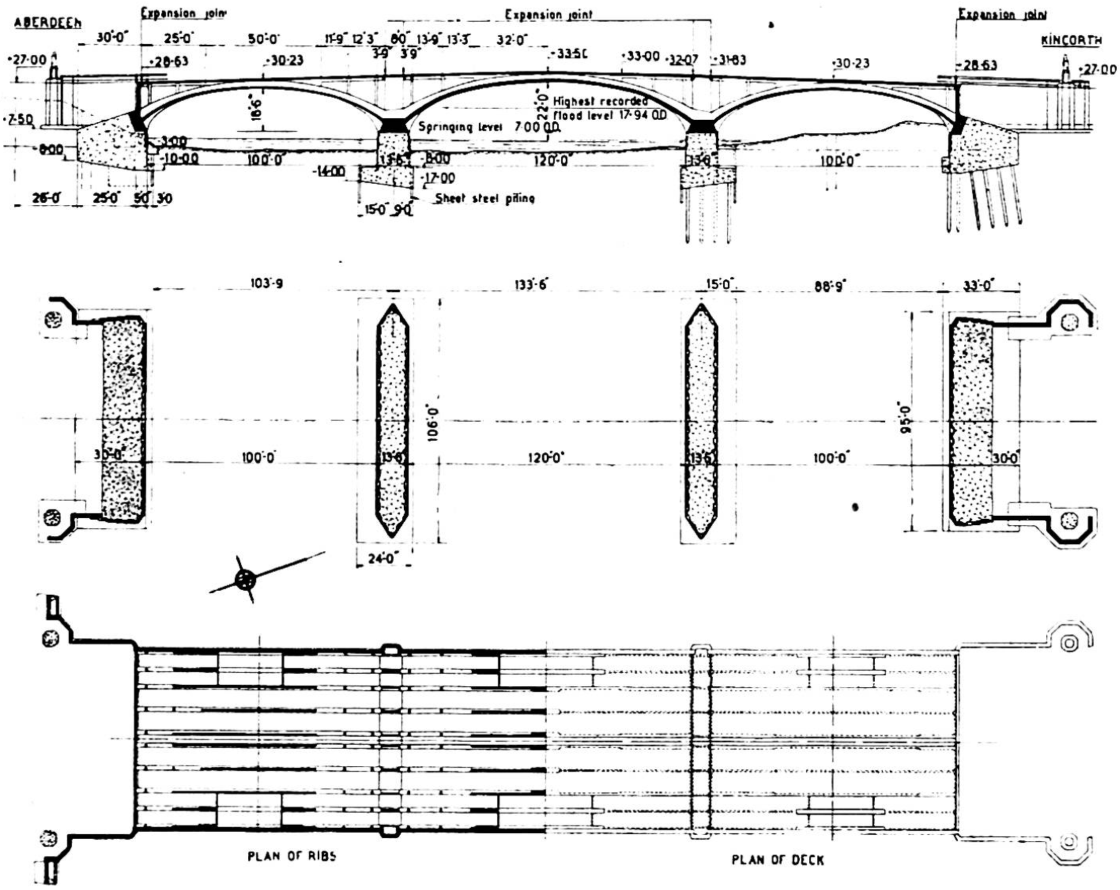
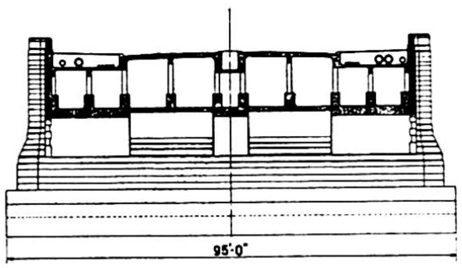
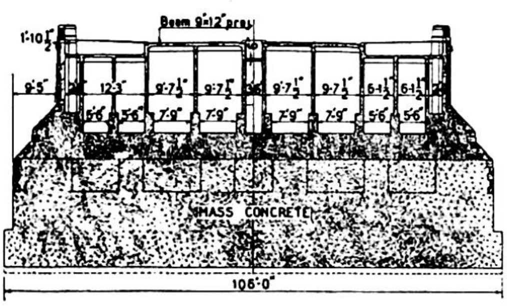


Fig. 1. General plans and sections of the King George VI-Bridge.

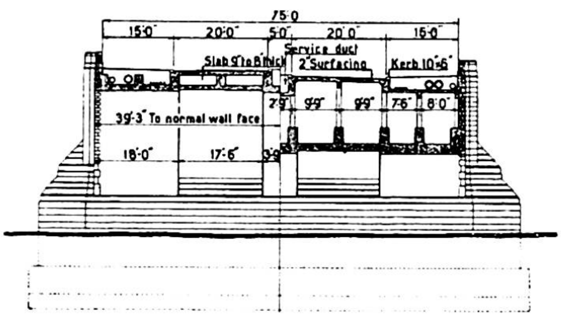


Abutment

Fig. 2, 3 and 4. Section through abutment, river pier and cross section at crown and near springing.



River pier



Cross section

At crown Near springing

100 ft long respectively were mounted on trestles built on each bank. From these positions they were able to drive about sixty timber piles to the central portion of the staging to each side span. Beams and braces were added to these groups of piles and the cranes were moved and mounted on these stagings, from which they were able to cover the full area of each River Pier cofferdam.

The cofferdams comprised a rectangular wall of Larssen steel sheet piles of the interlocking type with the usual horizontal frames and struts. As the river is tidal and subject to sudden spates, the tops of the sheet piles had to extend above the level of the highest recorded flood, and the specification also required that the points should finish six feet below the lowest level of the bases of the Piers. The length of the Larssen piles was therefore 40 feet. They were driven with the use of McKiernan-Terry Steam Hammers, No. 9B, suspended from the crane jibs, and this was also the method for driving the whole of the temporary timber piles to the staging and temporary bridge.

As a result of experience gained in driving the steel sheet piles to the first cofferdam, where difficulty was met with by the presence of large boulders on the river bed, the Contractors removed these boulders over the area of the subsequent cofferdams as a preliminary operation. Fig. 6 shows the state of construction at this stage.

Upon the completion of each cofferdam and the pumping to remove the water, excavation was carried out, mostly by hand, and the bottom trimmed to the correct levels and slope as shown on the contract drawings. The character of the strata below these levels was investigated and found to be a soft clay mixed with fine sand. It was decided that this foundation was incapable of carrying safely the calculated pressures and therefore the

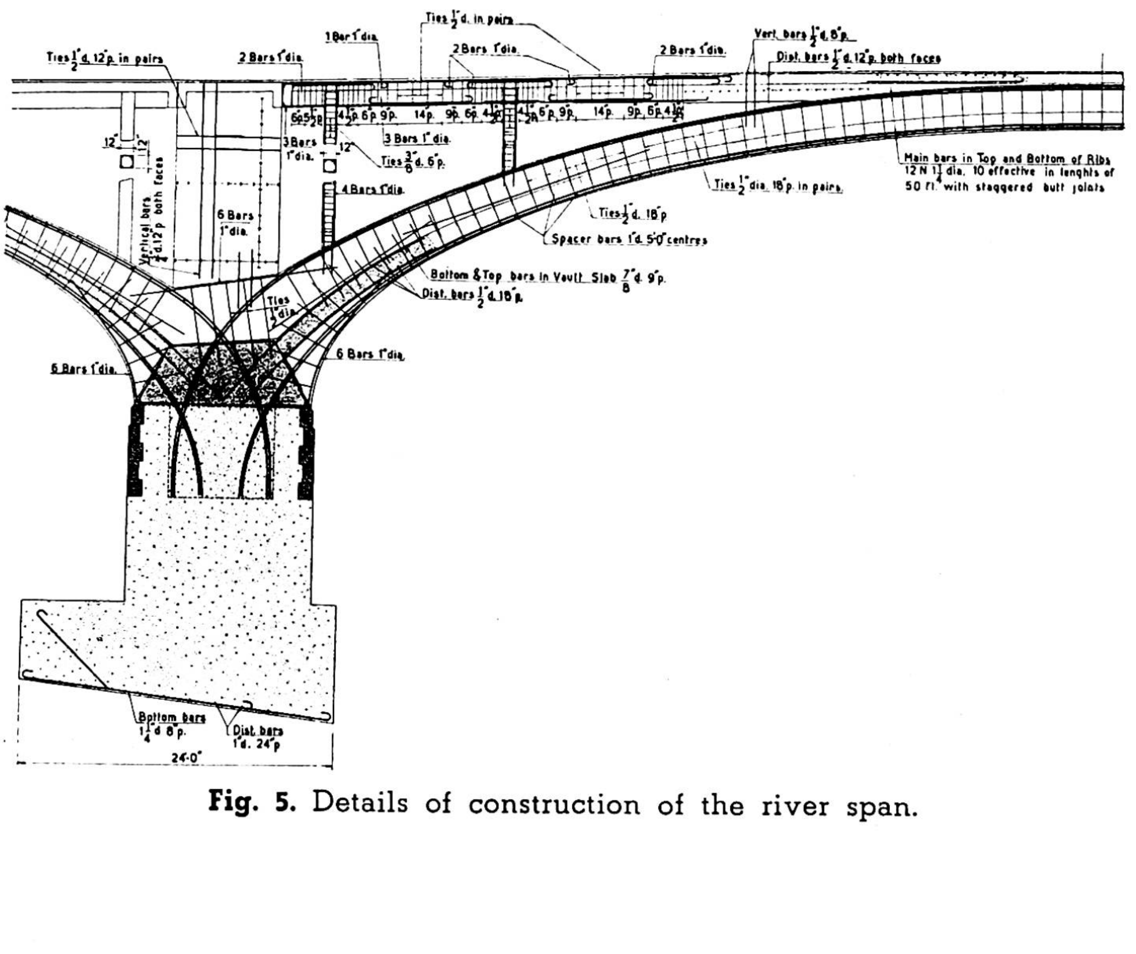


Fig. 5. Details of construction of the river span.

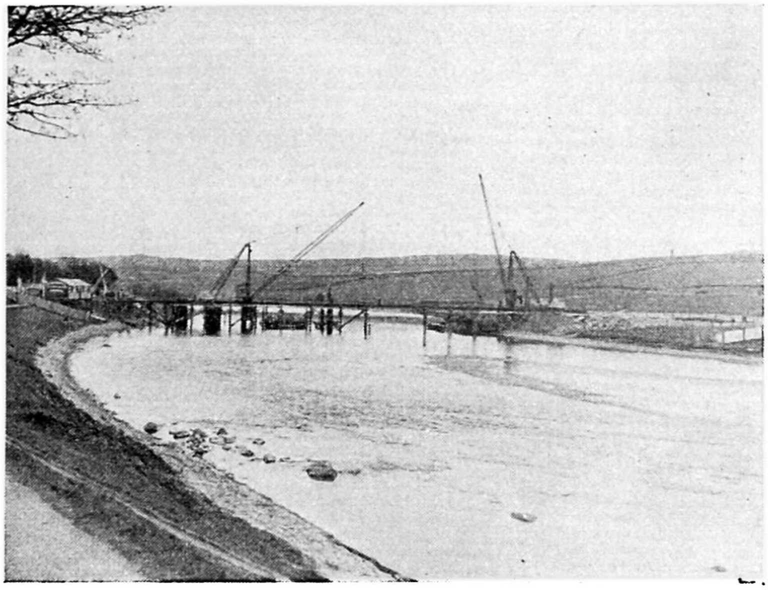


Fig. 6. General view from North Bank in early period of construction.

reinforced concrete piles were used under the River Piers and Abutments. One test pile was driven in each cofferdam, and the information so gained enabled the lengths of the remaining piles to be derived. These lengths varied from 35 ft on the South side to 25 ft in the North Abutment.

The Contractors devised an ingenious method of casting the piles in the limited space at their disposal. Two small pile yards were prepared and ten piles cast in each yard on alternate days. Thus, the piles in one layer had time to set sufficiently to enable them to carry the weight of the next layer. This was repeated until each comprised ten layers in height, and the ground area used for casting and storing about 200 piles by this means was only that necessary for 20 piles. It was, of course, known that the piles firstly cast would not be required to be driven before those in the upper tiers had matured sufficiently to be driven in the work. Fig. 7 gives a view of the piles in a stack seven tiers high.

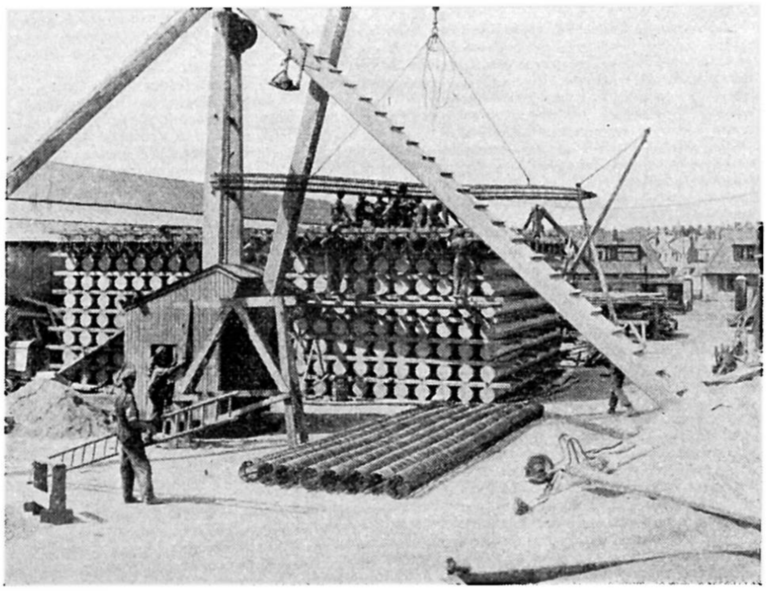


Fig. 7. Fixing reinforcement for piles in casting yard showing stacking of piles.

The reinforced concrete piles were driven from a piling frame carried on timbers resting on the bottom of the excavations. At first a drop hammer weighing 2 1/2 tons was used, but it was soon discarded in favour of a single-acting steam hammer. The specified penetration set was reached at the anticipated level below the foundations where a hard stratum was reached sloping downwards from the North to the South bank with a noticeable inclination along the length of the cofferdam where the driving was harder at the West end than that experienced at the East end.

During these operations the temporary bridge was completed, together with the driving of the remaining piles to the staging in all three spans. Simultaneously the construction of the Riverside Drive retaining walls, 800 ft long, with granite facing, including the re-grading of the road along the North bank, steadily progressed.

Salmon fishing is of great value in the higher reaches of the River Dee. The authorities who control these fishing rights imposed a restriction on the number of supports to the temporary staging with a view to reducing to a minimum the obstruction to salmon passing through the bridge false-works. It was observed during pile driving that the salmon halted a definite distance away from the bridge until pile-driving ceased for the day, and then they resumed their passage up the river.

The granite facing stones to the cutwaters and piers were being dressed during this early period of construction. All the granite was obtained from the Kemnay Quarries, and was supplied and dressed by Messrs. J. Fyffe, Ltd., and Messrs. George Hall, Ltd. A laying-out floor was provided on the South bank, where full-size templates of the Voussoir stones to the arches could by prepared. Use was subsequently made of this full-size setting out to obtain the correct curve to the longitudinal reinforcing bars in the Arch ribs. The cutwater stones to the Piers were erected at the mason's yard with dry joints so that the approval of the Consulting Architect could be obtained before being built in the work.

The main concreting of the piers could now proceed. These were brought up to springing level with their granite facing, and large pockets were formed in the top of the piers for the subsequent reception of the reinforcement in the Arch ribs, after which they were filled solid with concrete (fig. 8 and 9). This arrangement was made to permit the early removal of the upper portions of the steel sheet piling, leaving the portion below the top of the enlarged base permanently in position. The cutting of the sheet piles was done below water by an oxy-acetylene flame, and presented no difficulties. Similar arrangements were made with regard to the piles in the Abutment cofferdams, except that the piles along the ends for a distance of 13 ft and along the back were entirely removed.

Having reached the stage where the two Piers and Abutments had been completed up to springing level the two 5-ton Scotch derricks were moved to positions behind the Abutments, and the upper portion of the staging to the three river spans could now be completed. Fig. 9 gives a view of the South Pier with the arch shuttering in place. Allowance was made for the easing of the staging when the vault slabs and ribs had been concreted by placing hard-wood folding wedges under the points of support. The timber sheeting was covered with galvanised steel plates 0.035 inch thick and 4 feet square, firmly fixed to the sheeting. This was specified so that the exposed soffit would not be marred by frequent impressions of

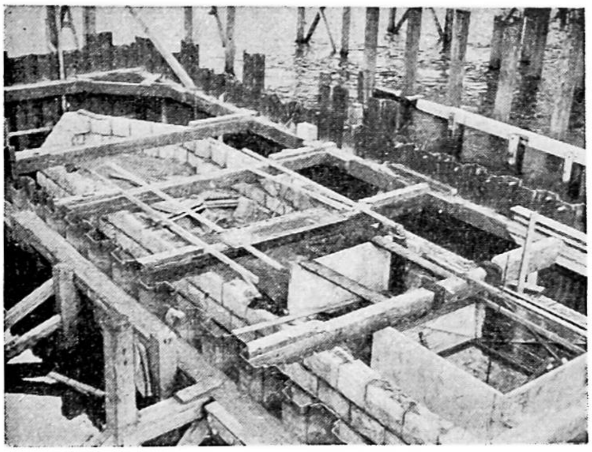


Fig. 8. South Pier showing first two courses of granite and formation of temporary pits, for subsequent reception of arch reinforcement.

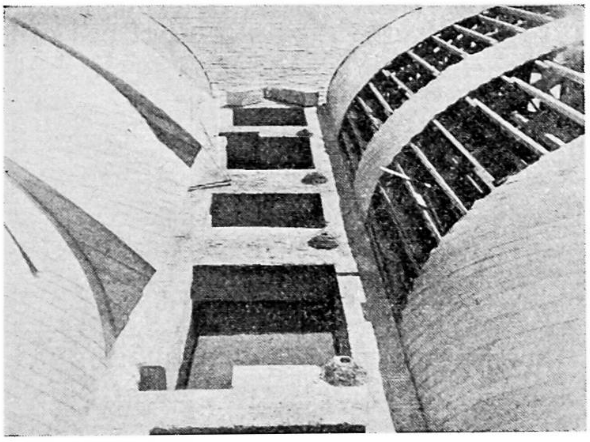


Fig. 9. South Pier. Arch shuttering in progress.

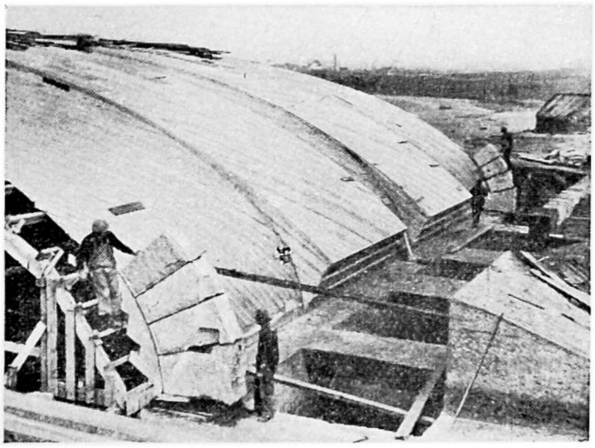


Fig. 10. South Abutment showing first four voussoirs in position.

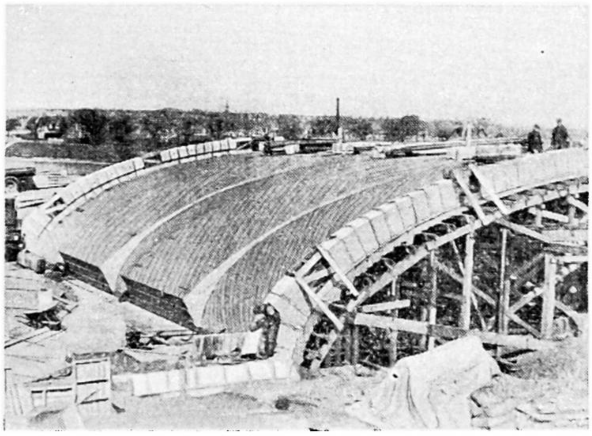


Fig. 11. South Arch span with voussoirs in position and temporary gaps formed.

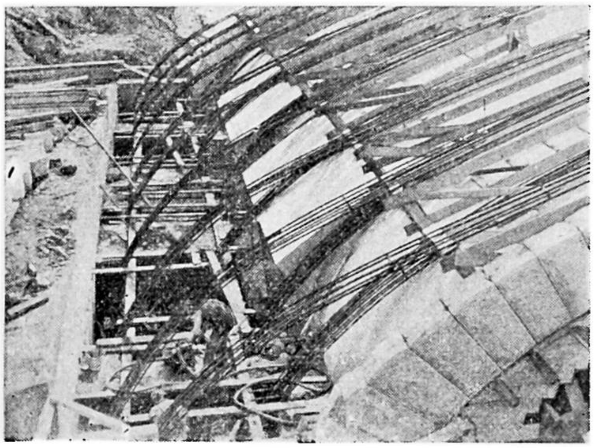


Fig. 12. Reinforcement in arch ribs.

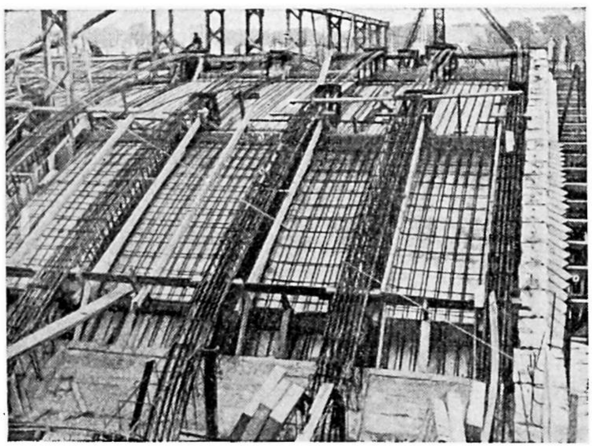


Fig. 13. Centre span reinforcement prior to concreting.

shuttering joints. The Voussoirs were built in position but with dry joints opposite the transverse gaps in the vault slab and ribs (See fig. 10 and 11). Concreting of the vault slab and ribs was carried out to a predetermined programme, and after five weeks had elapsed since the last section of this concrete had been poured, the gaps were also concreted. Fig. 12, 13 and 14 illustrate the work at the various stages during the concreting of the arches.

During this stage of the work, a very severe period of low temperature was experienced when thick ice nearly covered the full width of the river. The Contractors employed men for four days and nights to break up the ice around the timber piles and River Piers and to keep a channel open to prevent a heavy jamb of ice against the partially constructed bridge. (See fig. 16 and 17). A similar state of the river was experienced in the following winter but most of the staging had been removed, and therefore, the danger to the bridge was not so serious.

A temporary gantry was erected along the centre line of the bridge with supports at the positions of the temporary gaps and at the two Piers. This was raised to a height which would allow the deck slab to be constructed. A mixing plant for the concrete was located on the South Bank, the concrete loaded into trucks which ran along a railway for distribution to all parts of the work through open troughs and pipes. This plant arrangement served for the whole of the concreting to the vault slab and ribs, the temporary gaps and the deck superstructure. Fig. 15 is a general view of the roadway deck construction in progress.

The staging was lowered by easing the wedges after the elapse of one week since the last section of the temporary gaps were concreted. Careful records of settlement of the crown were made. In the case of the centre span this deflection was 0.42 inch during concreting of the vaults and ribs, and a further 0.48 inch was recorded immediately the arch staging had been entirely lowered clear of the arch soffit, making a total of 0.9 inch. An allowance of 1.5 inches had been made when setting up the staging and this was approximately the settlement when levels were taken about eighteen months after the staging was eased and removed. Further records were taken during the early life of the bridge which revealed small differences which could be explained by seasonal changes of average temperature.

During the main concreting of the arches, frequent crushing tests of concrete cubes were made. These gave results appreciably higher than those specified, and enabled the Consulting Engineers to permit some reduction of the periods specified between completion of the concreting and the striking of the temporary staging.

The exposed concrete to the underside of the Arches was treated by bush hammering. This removed any lines left by the joints between the galvanised sheets, and it exposed the texture of the stones in the concrete. The result was very pleasing and was a further proof of the high quality and uniformity of the concrete.

The granite-faced spandrel walls were built at a late stage in the construction, as laid down in the Specification, and were secured to the superstructure by ties between the columns carrying the deck and the concrete backing to the walls. Some of the vertical joints were left open until the latest possible date in order that any slight movement could occur without cracking the stone facework.

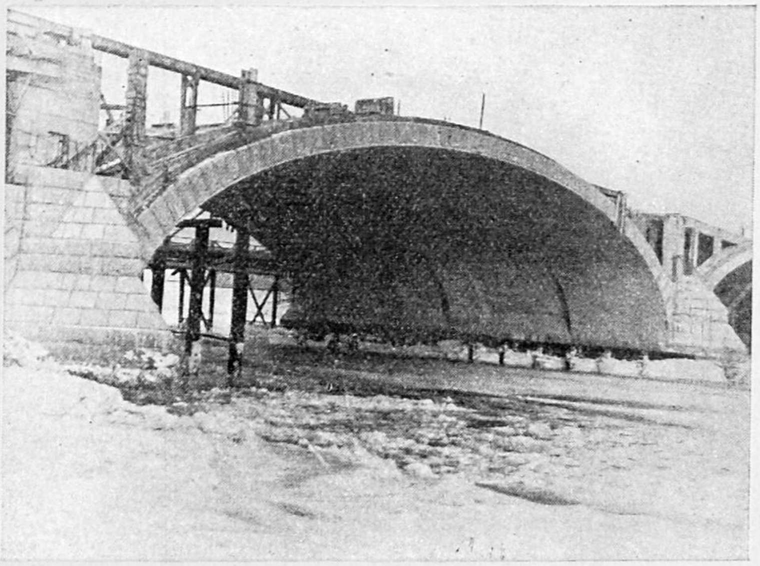


Fig. 14. Centre span arch with centering removed.

Provision has been made for permanent ventilation of the spaces between the arches and the underside of the deck. Small openings have been formed in the parapets over the Piers, and these are covered by cast iron grilles.

The Architect's design included for a large heraldic Lion carved from a granite block at each corner of the bridge. Foundations have been constructed for these features, but the carving for and the erection of the Lions have been postponed until the supply of labour is more plentiful.

The bridge is, however, embellished with eight carved coats of arms set in granite niches, one at each end of the River Piers and at the Abutments. These coats of arms represent those for the City of Aberdeen, the County of Aberdeenshire, the County of Kincardinshire, the Aberdeen Harbour Commissioners, the Incorporated Trades, the University, the Grammar School and Gordon's College. Fig. 18 gives views of the completed bridge.

Messrs. W. J. Anderson, Ltd. were also given the contract to build

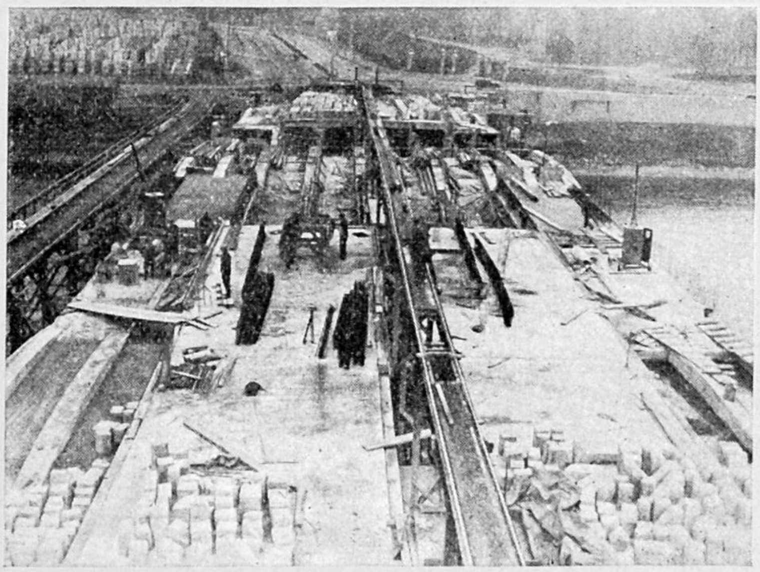


Fig. 15. General view with roadway deck in progress.

a small bridge on the South bank, situated about 450 feet from the centre line of the River Dee. The purpose of this bridge is to allow water to pass through the raised embankment in times of abnormal flood, but it also provides access below the main road for vehicular and pedestrian traffic. The bridge comprises two arches, 45 feet clear span, with a central pier, 7 feet wide. The width between parapets is 75 feet as for the River bridge. The overall length from end to end of the wing walls is 173 feet.

Granite again forms the facework to all visible surfaces except the soffit of the arches. The abutments and central pier are founded on reinforced concrete piles. The arch vaults are 12 inches thick at the crown and their intrados is semi-elliptical with a clear rise above springings of 14 feet. They are of constant thickness throughout the width of the bridge and earth filling on top of the vaults carries directly the roadway and footpath surfacing.

Both bridges were opened for traffic by Her Majesty the Queen on March 10th, 1941, in the presence of the King, the Lord Provost and many distinguished guests.

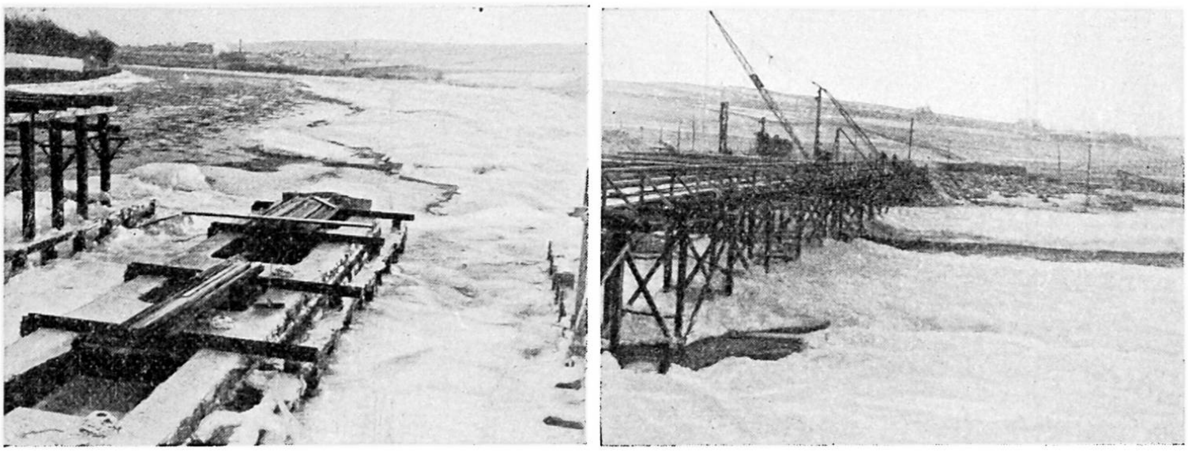


Fig. 16 and **17.** Ice and snow on the river, January, 1939.

Résumé

Description du projet et de la réalisation du nouveau pont en béton armé avec revêtement de granite au-dessus de la Dee, et dont l'inauguration par S. M. la Reine eut lieu le 10 mai 1941. Ce pont comporte 3 travées de 30, 36 et 30 mètres pour une largeur utile de $22^{m}50$.

Le projet a été conçu par M. T. F. Henderson, ingénieur M. I. C. E.; Considere Constructions Ltd., ingenieurs conseils, Westminster ; et Sir Frank Mears, F. R. I. B. A., architecte conseil.

Les arcs sont réalisés sans articulation et reposent sur des piles massives en béton. La nature du sol obligea de réaliser les fondations sur pieux.

Le début des travaux eut lieu par période de grand froid.

Zusammenfassung

Beschreibung des Entwurfs und der Konstruktion der neuen Eisenbetonbrücke mit Granitverkleidung, über den Dee-Fluss bei Aberdeen, eröffnet durch I. M. die Königin am 10. Mai 1941. Drei Spannweiten zu 100′, 120′ und 100′, und eine Breite zwischen den Geländern von 75′.

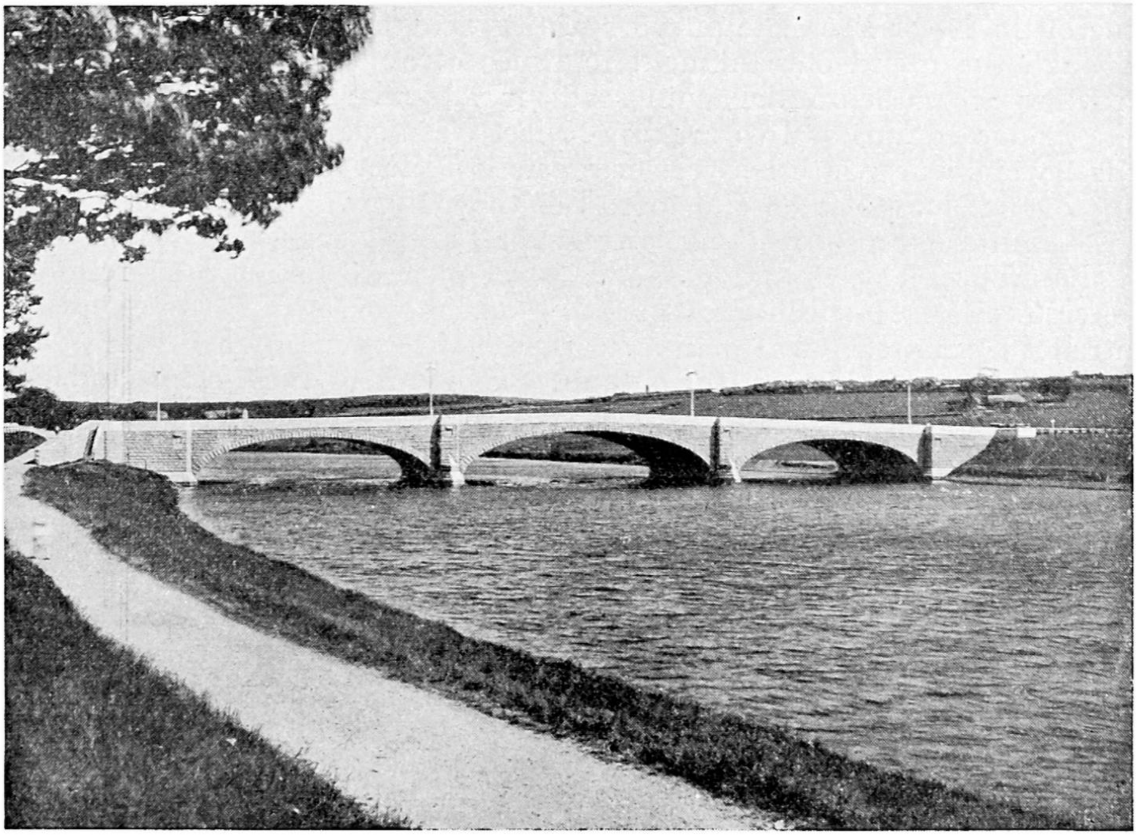


Photo A. J. B. Strackan

Fig. 18. Views of completed bridge.

Der Gesamtentwurf stammt von Stadt-Ingenieur Mr. T. F. Henderson, M. I. C. E.; beratende Ingenieure, Considere Constructions Ltd., Westminster, und Sir Frank Mears, F. R. I. B. A., beratender Architekt.

Die Bogen wurden gelenklos entworfen und auf massiven Beton-Flusspfeilern und Widerlagern abgestützt. Die Pfeilerfundationen waren notwendig, da sich beim Aushub innerhalb des Fangdammes weicher Baugrund zeigte.

Am Anfang der Bauzeit herrschte strenge Kälte und der Fluss war praktisch zugefroren.

Summary

Description of design and construction of the new reinforced concrete bridge faced with granite over the River Dee at Aberdeen, opened by H. M. the Queen, May 10th, 1941. Three spans 100 ft, 120 ft and 100 ft, and width 75 ft between parapets.

General plans by City Engineer, Mr. T. F. Henderson, M. I. C. E.; Consulting Engineers, Considere Constructions, Ltd., Westminster, and Consulting Architect, Sir Frank Mears F. R. I. B. A.

Arches were designed as hingeless, and supported on mass concrete river piers and abutments. Piled foundations were necessary due to the soft ground revealed by the excavations inside the coffer dams.

During early construction severe cold was experienced and the river was practically closed by ice.