Extension to the Auckland Harbour Bridge

Existing Bridge

In 1962, after only three complete years of operation, it became evident that the traffic over Auckland Harbour Bridge was continuing to grow much more rapidly than had been expected, and that it would not be long before the flow had reached the capacity of the bridge. By 1964 the average daily traffic had increased to 22,000 vehicles, and Freeman, Fox & Partners were asked to report on the feasibility and cost of increasing the traffic capacity of the crossing by 50-100 per cent.

The existing structure, details of which are given in Papers Nos. 6528 and 6514 published in the Proceedings of the Institution of Civil Engineers, had been so keenly designed that there was no possibility of its taking any additional load from roadways cantilevered at the sides, and attention was therefore first directed to duplicating the whole bridge. As usual in such cases it was found that the best alignment was already occupied and the next best position for a new structure would be as close as possible on the east side. The positions of the navigation span and the other piers would have to match the present ones, and, in fact, the new structure would take the form of a lateral extension. It was realized at once that a new truss structure alongside would inevitably spoil the elegant appearance of the bridge, of which the residents of Auckland are justly proud. Also, a great number of piers in the harbour so close together might well interfere with visibility necessary for navigation. On the other hand, to site the bridge some distance away would seriously increase the cost of approaches and make it very difficult, if not impossible, to use the same toll collection area.

Additional Side Structure

In the course of the investigation into the strength of the existing structure, it was found that the piers would be capable of carrying a slightly increased load without exceeding the safe limits of pressure on the bedrock under conditions of earthquake. According to New Zealand coded design for earthquakes, foundation pressures due to wind forces are not included with earthquake effects, whereas in the original design (made before the code was published) a moderate amount of co-existent wind forces had been allowed. Further investigation showed that it

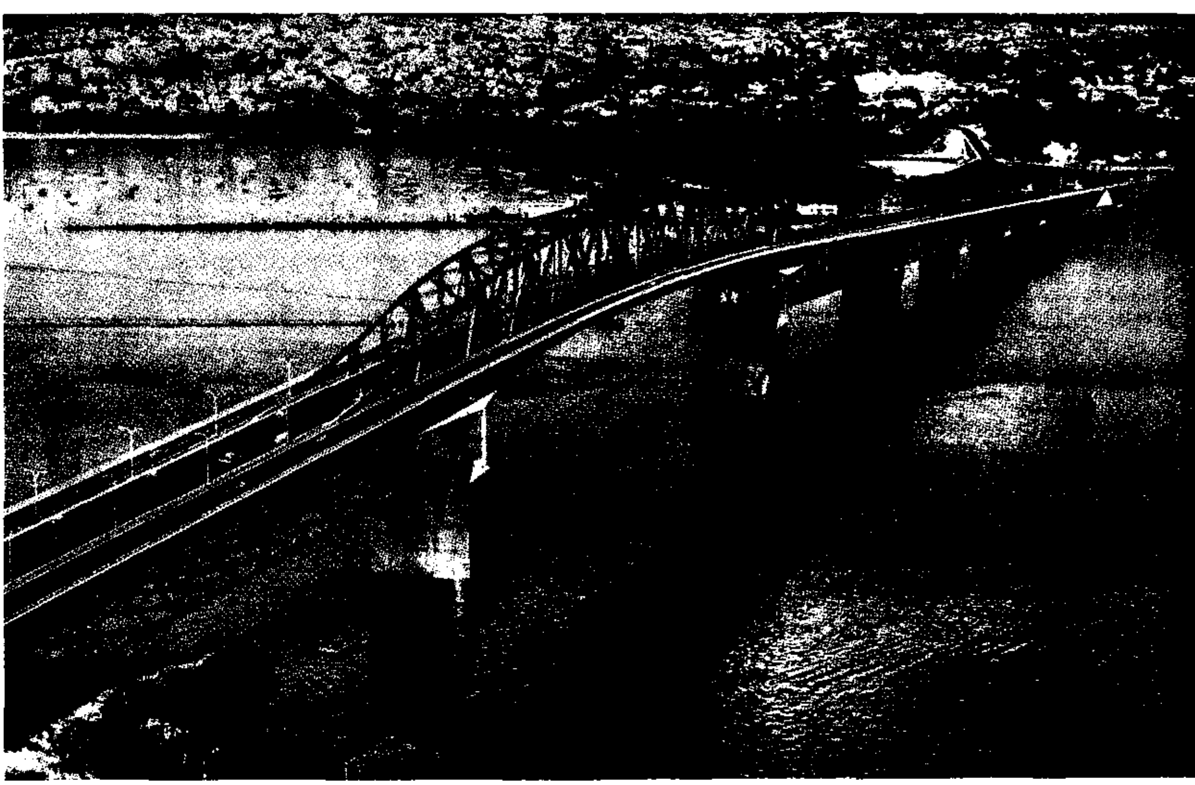


Fig. 1. The existing Auckland Harbour Bridge, with an artist's impression of the new structure superimposed.

would be possible to support a very light form of structure on either side of the bridge supported on brackets from the existing piers, and that it might be possible to devise a very shallow form of construction over the navigation span to maintain substantially the same navigation clearance without obscuring the present elevation of the truss bridge.

The design considered was a shallow box girder construction in welded high tensile steel, with the traffic running on a thin asphalt wearing surface laid direct on the top flange. In this way, the dead weight of the new structure is kept to a minimum.

Over the navigation span the deck rises to a level 2 feet 6 inches above the existing road, so as to increase the construction depth as much as possible. This is achieved by reducing the radius of the vertical curve to 5,300 feet, the minimum acceptable for speeds of 40 m.p.h. It was hoped to keep the underside of the new structure flush with the existing bridge and so maintain the full navigation clearance, but this was not found possible without considerably exceeding the generally acceptable limits of slenderness and flexibility. The navigation authorities were, therefore, approached with a request for a reduction in

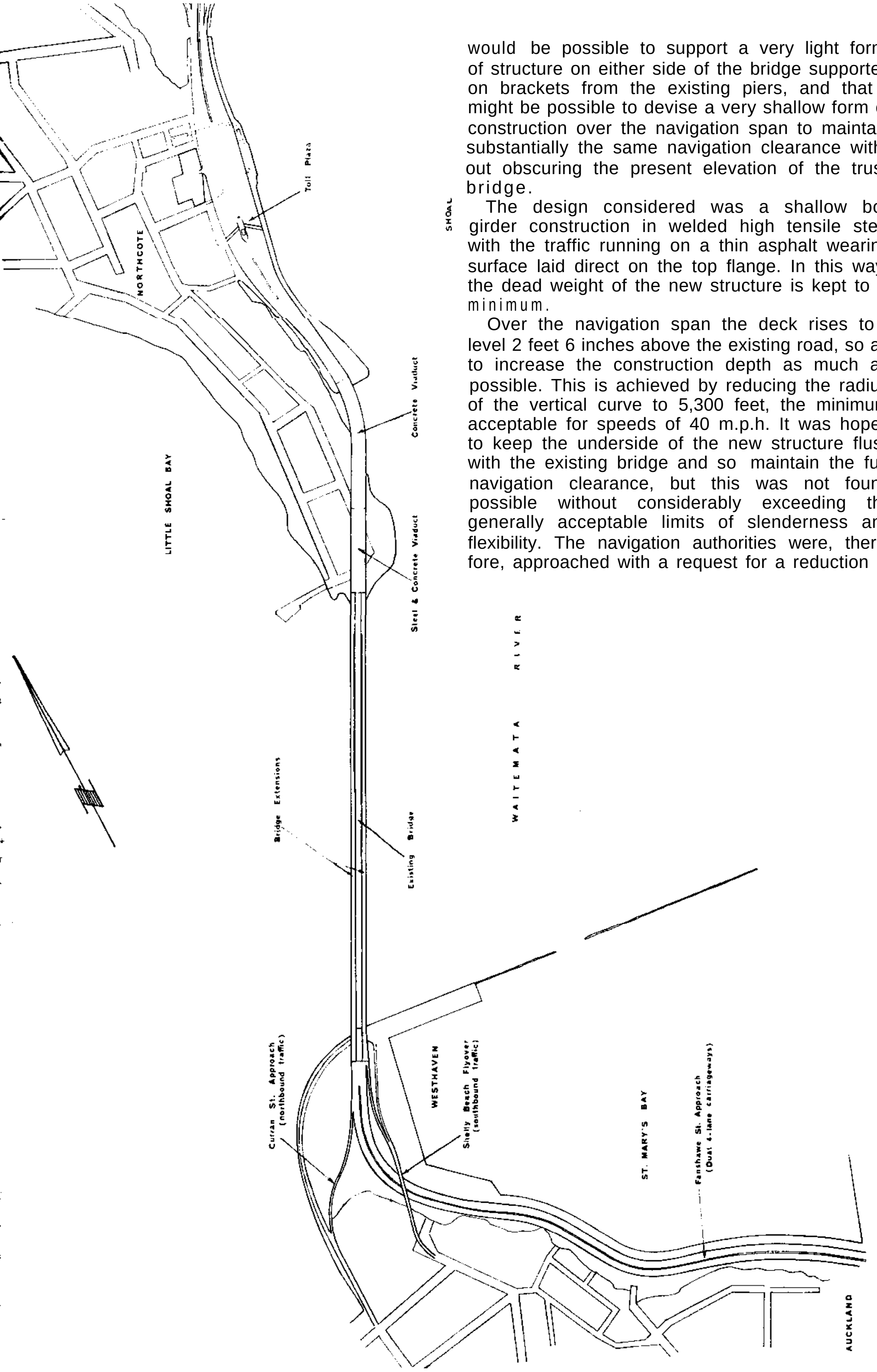
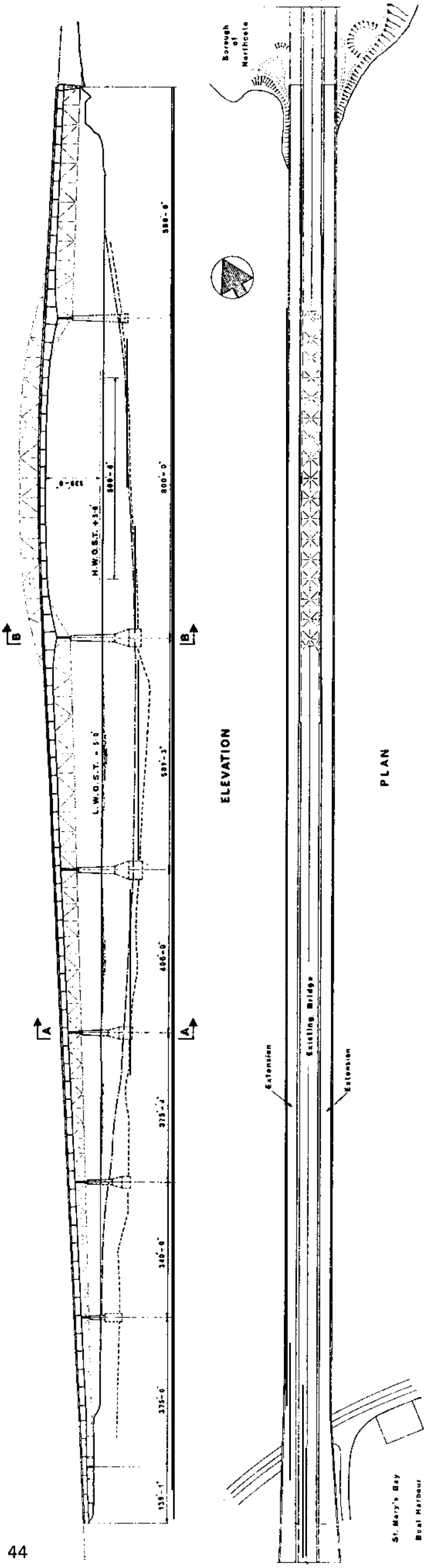


Fig. 2. Approaches to the Auckland Harbour Bridge.

headroom of 3 feet at the centre of the span, and to this, albeit reluctantly, they agreed. It is perhaps appropriate at this point to thank the Auckland Harbour Board for their public spirited attitude in accepting this reduction, without which the design problems could not have been satisfactorily solved.

The design was worked out in detail and showed a saving of at least £2 million compared with the cost of a new bridge, due to avoidance of new foundation work in the harbour. There is a further saving on approach viaducts and roads which in this scheme are more conveniently located.

It is equally important, especially to the residents of Auckland, that this scheme avoids destroying the general appearance of the bridge. From Fig. 1, which shows a photograph of the existing bridge with an artist's impression of the new structure superimposed, it will be seen that the two constructions blend well together.



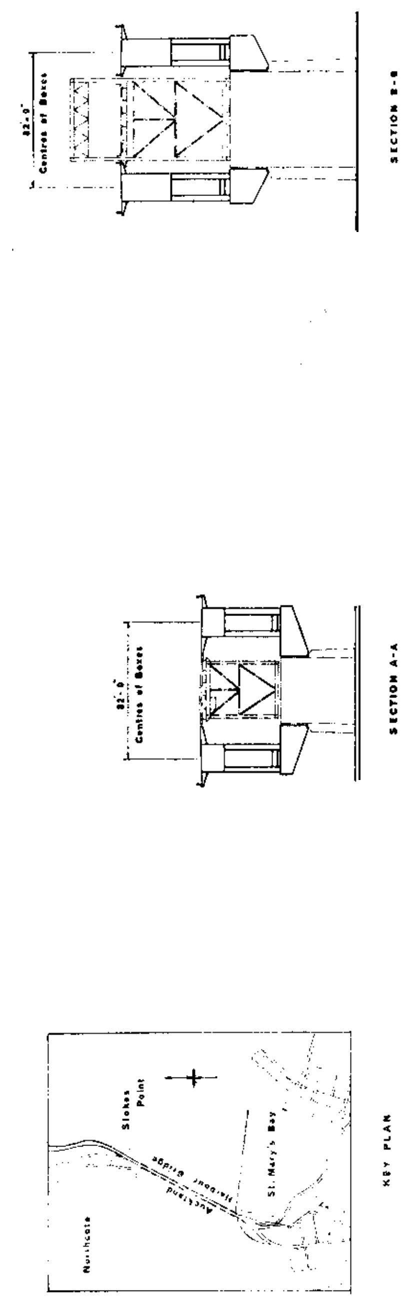


Fig. 3. Cross sections, elevations and typical details of the new steelwork, together with a plan of the bridge and its location.

The new structures are completely separate from the old, with a gap of an inch or less between them at deck level, but where the truss does not project above the deck a hard shoulder can now be accommodated between the new traffic lanes and the old. This will provide a much needed facility for disposing of breakdowns, which are a frequent cause of congestion on the present 42-feet wide four lane carriageway.

The new structures are continuous for the whole length of 3,600 feet with an anchorage to take longitudinal forces at the north end, where hard rock is near the surface, and a single expansion joint at the south end where the structure rests on a concrete abutment. At the intermediate support points deep rockers are provided to allow free longitudinal movement. In this way the piers are relieved of all horizontal earthquake forces acting on the bridge in the longitudinal direction and have to resist only those acting transversely. This they are able to do without exceeding the safe pressure on the mudstone rock.

Each of the side extensions has a 36 feet-wide deck made up of two 12-feet traffic lanes, a 7 feet hard shoulder on the inner side and a 3 feet 6 inches marginal strip on the outer side. Where the truss of the existing bridge rises above the deck, there is no hard shoulder but an inner marginal strip 2 feet 6 inches wide. The continuous box girder is 17 feet wide and 14 feet deep, except in the navigation span where the depth is increased to 30 feet 6 inches at the main piers and reduced to 12 feet 6 inches in the centre. At the south end the depth is tapered to 9 feet 6 inches at the abutment to provide greater headroom over an access road to the yacht club.

The deck plate varies in thickness from $\frac{7}{16}$ inch to $\frac{11}{16}$ inch and is stiffened by inverted troughs at 2 feet centres welded to its underside. There are cross beams and vertical stiffeners at 15 feet intervals. The boxes are designed to be fabricated in 45 feet long sections matched together before erection, although these dimensions may be varied to suit the successful tenderers erection scheme. All the site joints are welded. Fig. 3 shows cross sections, elevations and typical details of the new steel work.

The new bridge, excluding approach viaducts and roads, was estimated in 1964 to cost about £3·5 million and to take three years to construct. International tenders for this work were called for in April 1965, and the contract was awarded in 1966 to a Japanese firm for £3,713,000.

Approaches

The present approaches on the north side consist of a 600 feet-long steel viaduct with a concrete deck and 950 feet-long reinforced concrete viaduct running along the water line of Shoal Bay to the toll plaza. The former viaduct has spans of 54 feet and the latter spans of 60 feet. To the north of these there is a short length of embankment before the toll plaza is reached. These viaducts will be extended by building additional structures both sides, each carrying a 24-feet carriageway, these new carriageways being joined on to the existing ones to make an open deck eight lanes wide. The arrangement of these lanes may be varied to suit conditions. The toll plaza itself will be widened and extra booths added.

On the south side there is a short steel viaduct to the existing bridge, but the main bridge extensions will run alongside this up to the abutment, thus avoiding any separate extensions to the approach viaduct.

The approach roads on the south side consist of a dual carriageway of two lanes a side running along the shore line from Fanshawe Street to the bridge. This will be increased in width to have four lanes per side. Two further roads join the Fanshawe Street approach just short of the south abutment, these are the Shelly Beach Flyover and Curran Street approach. Both are one-way roads, and it is not proposed to alter them since the three roads together can easily carry the traffic capacity of the bridge when it is working with six lanes for the major traffic flow and two for the minor. It may be mentioned here that since the bridge has a gradient of 1 in 20, heavy vehicles are slowed up considerably and cause the capacity of six lanes to be less than the six lanes of the flat approach roads.

The junction between the Fanshawe Street approach and the Shelly Beach and Curran Street approaches will be suitably widened to allow for weaving and merging movements which will occur here. The southern end of the main bridge extensions will be tapered out to meet this widened portion. These approaches are shown in Fig. 2.

Toll Collection and Traffic Control

The present toll plaza is some 2,000 feet long and has ten toll booths, the centre eight being reversible. On the eight-lane bridge 20 booths will be required, 15 of them reversible. The plaza will have to be widened by 150 feet, ten acres being reclaimed from the shallow water of Sulphur Beach. The toll administration buildings will have to be extended, and it is proposed to site some of them in the centre of the plaza as this gives certain operational advantages. Pedestrian and vehicular subways will give access across the full width.

The present toll collection equipment has proved very satisfactory and similar equipment may be used for the extension. However, advantage will be taken of recent developments in this field to ensure that the best equipment is installed, which will save manpower and give comprehensive traffic data.

Methods of traffic control are continually improving. Overhead lane indicators, television surveillance systems and better breakdown services are examples which are being considered for the present bridge. Similar methods will be appropriate for the enlarged bridge.

Summary of Costs	£
Alteration to main piers and constructing new anchorages	550,000
Main superstructure	2,700,000
Approaches	1,300,000
Toll plaza and equipment, etc.	700,000
Total	5,250,000

(This is based upon a paper presented by Sir Gilbert Roberts BSc, FRS, MICE at the IRF Fifth World Meeting.