2. Metropolitan Roads and Bridges.

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All great civilizations have arisen from and depended on the development of transport facilities by land or by sea. Over their roads and bridges, their waterways and wharves have come the commerce that has nourished them. Two thousand years ago, Rome built up her World Empire upon a highly efficient transport system which was the main factor not only in bringing her enormous wealth in commerce but was also an essential factor in her defence against foreign aggression.

"Commerce alone begetteth wealth" wrote Bacon, England's greatest philosopher, over three centuries ago, and it is even more true to-day. Commerce, the life blood of the nation, flows along the arteries of transport, and to-day if we would free the blockage of commerce that is impoverishing the world, we must endeavour to clear the arteries and remove all barriers, both physical and political, from transport and travel.

After an interval of some years, Melbourne has shown her appreciation of the pressing need for more transport facilities by constructing, this Centennial year, two new river bridges, thus showing herself sensible of the needs of advancing civilization with its increasing demands in transport.

In this short paper it is possible merely to mention some of the features of our Metropolitan roads, and to give a list of our Metropolitan River Bridges, other transport facilities being described by the engineers concerned with railways and waterways, tramways and airways.

When Melbourne was founded, the area from Prahran to the Bay was a series of marshes. Above the landing place near the present Customs House, a deep creek brought the water from the nearer hills on the north into the Yarra below the reef—since removed—that then kept the fresh water upstream free from salt tidal influences. The choice of routes for early roads and ferries was dictated by the position of firm ground approaching Melbourne through this morass.

With wise foresight, and apparently an appreciation of the fact that the location was ideal for a great city, the township was laid out on noble lines. This we owe to Robert Hoddle, then senior surveyor of the Port Phillip District, and later, after Separation, Victoria's first Surveyor-General. Rectangular in plan, the sub-division provided, for main streets, a width of ninety-nine feet, and for secondary streets or lanes, thirty-three feet. The latter have since proved to be a mistake.

To Hoddle, Melbourne owes also the fine boulevards of St. Kilda Road running southwards, Victoria and Wellington Parades to the eastern suburbs, and the Flemington and Sydney Roads to the North.

The Yarra River was crossed by boat until 1838, when William Watts established a punt just above the present site of Princes Bridge. Later a ferry was conducted by Mr. M. Monaghan, and in 1845 a temporary wooden bridge was built by the Melbourne Bridge Company for toll purposes at a cost of £400 some distance below where Princes Bridge now stands. Thus the St. Kilda Road-Swanston Street artery was established. The timber bridge gave place in 1850 to Melbourne's first stone bridge, a handsome single masonry arch of 150 feet clear span copied by its builder David Lennox from the celebrated Eaton Bridge over the Dee. When Melbourne began to realize her rapid growth and evident destiny, this bridge was found to be too narrow; and to prevent the frequent disastrous flooding of South Melbourne, it was clear that the river itself needed widening and deepening and the St. Kilda Road approaches required relocation and raising.

Competitive designs were called for, that of Messrs. D'Ebro and Grainger being accepted. The bridge, with a 99 ft. roadway, was completed in 1888, the contractor's engineer being Mr. George Higgins, M.C.E., with whom was associated Sir John Monash who was later to erect the Fairfield Railway Bridge and the Swing Bridge over the Saltwater River, and also, with the writer as partner, the Botanical Bridge at Anderson Street, the first important reinforced concrete structure in this State. Later, his firm also erected the picturesque new reinforced concrete bridge at Church Street.

None of these bridges has been expensive as compared with the bridges of other capital cities. Only three of all those erected across the Yarra have cost more than one hundred thousand pounds, viz:—the Princes Bridge (1888), the Church Street Bridge (1924), and the Spencer Street Bridge (1929).

The cheapest have been the Botanical Bridge, for which the late Carlo Catani was primarily responsible, completed in 1898 at a cost of £8,000, and Victoria Bridge. The latter was a prize-winning design by Messrs. Fraser and Chase, junior engineers of the Victorian Railways, and was constructed in 1884 by the late Mr. Charles Rowand, along with the then engineer for Richmond City, at a cost of £7,300. This cost was remarkable, considering that the structure was 340 feet long, and at an average elevation of 68 feet above the river, with a gradient of 1 in 25. The unusually steep deck gradient was adopted in order to link up the low-lying area on the west side, occasionally subject to floods, with the road on the east side which goes into a deep cutting at about 45 feet higher level. The cost quoted above includes approaches and road work, land purchases being effected by public-spirited private owners. The extraordinary cheapness of this structure was due to a series of experiments made in the Melbourne University by the late Professor W. C. Kernot, on the question of the minimum weight of steel needed to give the maximum strength and rigidity for a truss structure. He first established a ratio of depth to span, and then evolved a design, similar in analysis to that which Mr. D. A. K. Waddell, of New York, had named the "A" truss. Unfortunately, the designers placed it with too steep a gradient, and the bridge had to be temporarily closed while the east abutment was

raised, increasing the initial cost of £4,800 by £2,500. The bridge design was a triumph in its day for the Melbourne University Engineering School, and received the highest praise from contemporaries abroad.

Unfortunately, however, the fact that the bridge had thrice subsequently to be strengthened prevented the public from realizing its merit, and, like many other innovations when launched with insufficient funds, it fell under an undeserved obloquy. First its gradient was changed to 1 in 33; it was later widened from 20 feet to 36 feet for the tramways by the late Mr. George Duncan, and again, on the electrification of the tramways, was strengthened by Mr. B. A. Smith, M.I.E.Aust., at a cost of £16,000. When finally the bridge was condemned in 1924, by the writer as engineer for the City of Richmond, his recommendation as to the cheapest design perpetuated this type. The subsequent reconstruction by the Railway engineers has also been on the original lines, and the structure is well worthy of study. It is regrettable nevertheless that a single arch bridge could not have been thrown across the river to enhance the beauty of the lofty cliffs on the left bank.

The Fall's Bridge—now Queen's Bridge, was designed by Messrs. Checchi and Catani of the Public Works Department to the general lines of a prize design submitted by Mr. Rampart. It was opened in 1889.

An interesting Metropolitan bridge was at Church Street, Richmond, the first structure being an iron box girder originally made for use in the Crimea. It was superseded in 1924 by the present graceful reinforced concrete bridge, comprising 2 side arches of 97 feet and a central span of 106 feet, the deck width being 66 feet.

As far as roads are concerned, early surfaces were of macadamized construction which soon proved unable to stand up to the ever-increasing city traffic, and, in the 80's, replacement with wood paving on concrete foundations was commenced. The first claim of the Melbourne roads to engineering attention overseas was when Mr. A. C. Mountain, M.Inst.C.E., made the outer world aware of the advantages of Australian hardwood as a surface paving. (*Proc. Inst. C.E.*, Vol. XCIII, p. 374). He later introduced the modern method of protecting wood blocking with a thin asphaltic or bituminous carpet, with which most of Melbourne's roads are now covered.

In Richmond's roads, a system of using a rich watertight mix of concrete laid down in one coat of uniform thickness was pioneered, the extra strength at joints and margins being given by double reinforcement at the edges. On these roads, for the last twelve years no attempt has been made to maintain a wearing carpet, the aggregate of hard local basalt, with French coefficient of wear of 11, giving excellent wearing quality to the surface of the concrete itself.

The boulevards, already mentioned as forming the approaches to the city, show excellent examples of modern road construction.

St. Kilda Road, a worthy approach to any city, comprises a series of paths and roadways separated by ornamental plantations and lawns. The overall width is three chains, a central wood blocked roadway of 63 feet 6 inches, carrying a double track tramway, two 30 feet carriage ways also wood blocked, and tarred pathways of 10 and 9 feet. The plantations have an aggregate width of 55 feet 6 inches.

The Sydney Road and other boulevards also are well laid out and planted to provide attractive entrances to the city proper.

What has been done to such avenues as the St. Kilda Road, and the beautification of some parts of the Yarra, show to anyone who remembers these before the Royal Celebrations at the beginning of this century, that the wonderful material advancement of the first part of Melbourne's history has been outdistanced by the cultural and aesthetic progress of the last generation. So we are emboldened to expect that in the bext generation the holocaust of accidents, and the life-shortening delays at bottlenecks and narrow intersections, will soon be a thing of the past.

Rapid transport, both road and rail, demands the ultimate elimination of level crossings. Life is too short to be further curtailed or shortened. The needs of national life to-day re-echo in a different sense the words of England's greatest queen—Elizabeth—" One million of money is not enough for one moment of time."

LIST OF METROPOLITAN ROAD BRIDGES OVER THE YARRA RIVER.
(*From Heidelberg to the Bay.*)

No.	Name of Bridge.	Type.	Constructed by	Date
1	Heidelberg	Timber truss on Masonry Piers.		
2	Burke Road	Reinforced Concrete Beam and Slab	P.W.D.	1926
3	Fairfield Railway (now road bridge)	Steel Trusses on Masonry Piers	Railways	1889
4	Studley Park (footbridge)	Suspension	P.W.D.	1929
5	Johnson Street	Iron plate girders on iron columns	Municipal	1876
6	Walmer Street (footbridge)	Pin-jointed girder	P.W.D.	1891
7	Victoria Street	(*a*) 4-60ft. A type steel deck girders on steel cylindrical columns	Municipal	1882–3
		(*b*) do. widened	Municipal	1890
		(*c*) do. strengthened	Railways	1933
8	Hawthorn	(*a*) 2-60ft. and 1-160 ft. spans, iron lattice girders	Municipal	1860
		(*b*) do. strengthened	Railways	1930
9	Wallen Road	(*a*) 4 steel girder spans	1 Municipal	1881
		(*b*) strengthened and widened	2 M. & M. T. B.	1916
10	Grange Road	Under construction	Railways	1934
11	Church Street	(*a*) iron box girders	P.W.D.	
		(*b*) r.c. arches — 3 spans—total length 320ft. width 66 ft.	Municipal and M. & M. T. B.	1924
12	Punt Road (footbridge)	3—iron girder spans on cylindrical piers	Municipal	1899
13	Botanical (Anderson Street)	3—95 ft. r.c. arches	P.W.D.	1898
14	Princes Bridge	(*a*) timber bridge (below present site)	Private	1845
		(*b*) 1-160ft. masonry arch	P.W.D.	1850
		(*c*) 3—iron arch spans totalling 340ft. on masonry piers	P.W.D.	1888
15	Queen's Bridge	5 arched steel girder spans	P.W.D.	1889
16	Spencer Street	3 spans, central cantilever, 130ft., steel on r.c. piers.	Railways	1929