CONCRETE ROADS and Their Construction

BEING A DESCRIPTION OF THE CONCRETE ROADS IN THE UNITED KINGDOM, TOGETHER WITH A SUMMARY OF THE EXPERIENCE IN THIS FORM OF CONSTRUCTION GAINED IN AUSTRALIA, CANADA, NEW ZEALAND AND THE UNITED STATES OF AMERICA

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AUSTRALIA.

In Australia some experiments in reinforced concrete road construction have been carried out at Melbourne, Sydney and Brisbane.

Melbourne.—An extended, and what may so far be called a satisfactory test with a reinforced concrete road has been made by the South Melbourne City Council on the west side of St. Kilda Road, on a section within the Council’s jurisdiction. It was carried out under the supervision of Mr. A. E. Aughtie, M.Inst.C.E., City Surveyor. Five different, but conjoint, sections of the road were laid with steel mesh reinforcement—longitudinal and transverse, and triangular—supplied by two different makers, and with plain concrete, in order that a comparative test might be made of their relative values. In March, 1914, one chain of road was experimented upon, 33 ft. being laid with plain concrete and 33 ft. with concrete and longitudinal and transverse steel mesh reinforcement. In June, 1915, 2½ chains of plain concrete road were put down; at the same time half a chain of concrete road with triangular mesh reinforcement was laid. In March, 1916, half a chain of concrete road with longitudinal and transverse mesh reinforcement was constructed.

The reinforcement in the several instances mentioned was laid in concrete 6 in. thick, while the plain concrete road was 6–8 in. The concrete mixture for the various tests comprised four parts of blue stone screenings, two parts of sand, and one of cement. The width of the road so treated is 24 ft., with 3 ft. of channelling on each side. The surface of the various sections was tar painted and sanded.

Reporting on the test, Mr. Aughtie said it had conclusively shown that there had been absolutely no wear on the surface, and to all appearances it was as sound as on the day on which it had been laid. A number of transverse cracks, however, had appeared in the plain concrete road and at the junction of the reinforced road, but very few had shown themselves in the latter. Taking the reinforced sections as a whole, the cracks were of a very minor nature and the structure gave evidence of durability.

In 1917 the Melbourne Harbour Trust laid an experimental stretch of two-course concrete roadway in South Wharf Road. The Engineer responsible for this work was Mr. C. W. K. Allison,
Chief Engineer of the Trust, and the latest report is that, except for the screed grooves, the concrete is as good as when laid. Indeed, the Melbourne Harbour Trust are so satisfied with this experimental length that they are contemplating the construction of further roads.

During the latter part of 1922, the Richmond City Council, Melbourne, whose Engineer is Mr. Rose, commenced the reconstruction, in concrete, of Bridge Street and Swan Street, each about a mile and a half in length. A tramway line runs down each of these streets, and the width of concrete on each side of the tramway is 21 ft. in the case of Bridge Road and 12 ft. in Swan Street.

These are one-course roads, and at the time of going to press portions of them were still under construction.

The Country Roads Board, Victoria, towards the end of 1922 laid several experimental stretches of roadway of different types with a view to obtaining comparative results. These included plain concrete, reinforced concrete, concrete with a bituminous carpet, and water-bound macadam. It will be interesting to watch the result of this experiment.

Fig. 88.—Western Motor Track, St. Kilda Road, Melbourne.
Sydney, New South Head Road.—Some time ago, the Woollahra Council, Sydney, experimented with a section of the New South Head Road, near Mona Road, Darling Point. There is a foundation of a depth of 6 in., consisting of concrete made in the following proportions: 8 cu. ft. of 1 1/2-in. blue metal, 8 cu. ft. of 1 1/4-in. metal, or "shivers," 10 cu. ft. of blue metal screenings, and 4 cu. ft. of cement. Over this layer of concrete is laid the reinforcement. Above this is the wearing course, which consists of a rich concrete mixture of two parts of blue metal screenings to one of cement. The length of road constructed is 160 ft., with expansion joints 20 ft. apart.

Brisbane, Isles Lane.—In a Presidential Address before the Brisbane Division of the Australian Institute of Engineers, Mr. E. F. Gilchrist, the City Engineer, gave an account of the concrete road-making work carried out in that city. The following are extracts from the address:

The concrete road in Brisbane had its birth in a modest fashion in Isles Lane, off Adelaide Street. The old surface was excavated, and the subgrade well rammed, the steepest slope being

Fig. 89.—New South Head, Woollahra, Sydney.
1 in 9. The concrete is two-coat work, the base coat being 4 of basalt metal, 2 river gravel, and 1 cement. To the 2-in. basalt was added 50 per cent. of 1-in. screenings. The work was laid in alternate slabs each of 50 sq. ft. (10 ft. by 5 ft.), and the joints lime-washed. Joints were vertical and angled slightly, so that each wheel blow struck the joint at different intervals. The wearing surface, 1½ in. thick, was composed of 2 parts of river gravel from 5-16 in. to 1-16 in., and 1 part cement. Pine grips 1 in. wide of triangular section, 6-in. centres, were tapped into the wearing surface to form a foothold for horses.

The base coat was well rammed, and the top coat well worked with a plasterer's trowel. The finished surface was slightly roughened with a wooden float. The work was not reinforced, and was carried out, including excavation, for 7s. per sq. yd. The surface was recently cut out by the Metropolitan Water Supply and Sewerage Board. Until then no repairs of any sort had been carried out upon it. It was completed in June, 1914. There is no doubt the work put into the concrete has been amply justified.

Isles Street.—The next concrete road job was Isles Street, built with a transverse slope to one side, the idea being to widen the lane when the old building occupying the site of the present Brisbane Club building was demolished. This, however, did not eventuate. The road was one-coat work, and the surface was left rough.

Dalgety’s Road.—In 1918 the City Council were asked by Dalgety & Co. to construct a first-class road leading from Florence Street to their wharves at Bulimba. This strip of road, only half a chain wide and 420 ft. in length, had, on account of the very heavy traffic, been costing over £300 annually in maintenance in water-bound macadam. The company, on the Engineer’s advice, decided to put down a concrete road, but not without some trepidation as to the difficulty horses might have in negotiating the grade, which was 1 in 18, on a concrete surface. The road was laid down in concrete at a cost of £1,013, or 14s. 1d. per sq. yd., over an area of 1,436 sq. yds. This included excavation and regrading. Advantage was taken during reconstruc- tion to improve the gradient, which was reduced to 1 in 21.

It was found after construction that horses had no difficulty in
negotiating the concrete surface, and the necessity of employing a reserve third horse, which had hitherto been necessary to pull the two-horse teams up the grade, was removed. The maintenance on this road during the past four years has not exceeded a ten-pound note, and has consisted only in periodic attention to the joints, which are kept filled with bitumen. The road was laid in two-coat work, the top coat or wearing surface being 2 in. thick, and the total thickness 7½ in. at crown, and 6½ in. at kerb. The standards set at the Chicago Conference on Concrete Road Building were followed as closely as possible in carrying out the work, with the exception that the road was not reinforced.

The bottom coat consisted of 4 parts blue metal, 2 parts gravel, and 1 part cement, while the wearing surface was composed of a rich mix, 1 part inch metal, 1 part screened gravel, and 1 part cement. No reinforcement was used except in the longitudinal joint, which was occasioned by the necessity of carrying out the work in two halves to provide for the traffic.

The slabs are 25 ft. in length, with bitumen paint joints. After four years of heavy traffic, most of which is steel-tyred, this roadway is in excellent condition. A few cracks have appeared, but prove no deterrent if attended to and kept filled with bitumen.

There is no doubt that the behaviour of this road had a great deal to do with the future of concrete-surfaced roadways in Brisbane, and if it had failed under heavy traffic the death knell of concrete-surfaced roadways in Brisbane would have been sounded.

Victoria Bridge.—In 1920 the Victoria Bridge Board was faced with the necessity of replacing the old wood-blocked surface of Victoria Bridge with some other material, and after an exhaustive inquiry, which included an inspection of Dalgety’s road, and acting on the Engineer’s advice, decided in favour of concrete. The main reasons that guided the Engineer in making this recommendation were that he felt satisfied on the results of Dalgety’s road that with care a concrete-surfaced road could be made strong enough to stand up to the exceedingly heavy traffic of the bridge, and would be much safer than asphalt from the point of view of slipperiness for the travelling public under present conditions.
The elements of cost and maintenance also entered into the decision.

However, it was decided first to do the down-stream half of the bridge as it was in a more dangerous condition, and the City Council were asked to carry out the work. A specification similar to that used on Dalgety's road was adopted, except that the roadway was reinforced, thus enabling the slabs to be much larger and reducing the number of joints, and, in addition, a better wearing stone than basalt was sought for the aggregate of the wearing surface, and Enoggera granite was substituted.

The work was carried out during May and June, 1920, and cost 20s. per sq. yd., including the removal of the wood blocks. The very high cost of the granite and the extremely difficult conditions under which the work was carried out contributed largely to the high cost. The roadway concreted was 1,040 ft. long and 22 ft. 6 in. wide. Each of the six spans of the bridge was concreted in three slabs, so that each slab was over 57 ft. in length.

The base coat was laid on the original concrete foundation of the wood blocks after the surface had been thoroughly cleaned and washed. No attempt was made to secure a bond to the old concrete, it being considered an advantage that the new slab should be free to take up expansion and contraction changes without being tied to the old work.

The composition of this coat was 4 parts of 2-in. blue stone metal, 2 parts fine river gravel, and 1 part cement. The wearing surface was composed of 3 parts granite aggregate and 1 part cement. The granite aggregate was made up as follows: 9 parts 1 1/2 in. gauge, 5 parts 1 in., 2 parts 3/4 in., and 1 part 1/2 in. gauge (the run of the crusher with the dust removed).

The pavement was reinforced with fabric laid immediately on top of the lower coat—that is, 2 in. below the surface. Plastic joints 57 ft. apart and 1/4 in. in thickness were provided between the slabs. The surface was brought to a proper camber by a heavy template operating transversely to the bridge and finished off with a dusting of 1 to 1 cement and fine gravel to take up any excess water brought to the surface by ramming. No trowel was used, the surface being finished straight off the rammer. Both coats were carried on continuously, the whole of the slab being completed each day so as to ensure the two coats being
monolithic. The surface was then covered with sand and kept wet for ten days, and after fourteen days the traffic was turned on.

As in the case of Dalgety's road the concrete was mixed by hand—in fact, it would have been impossible to use a machine in the confined space available for work. Only one half of the width was available at a time, the very heavy tram and vehicular traffic having to be maintained. On the first half completed, before traffic was turned on, the surface was given a good coat of river gravel as a temporary protection against the continuous and concentrated stream of traffic on a 10-ft. strip. This gravel was allowed to remain, and, owing to the volume of the traffic and the wet weather obtaining at the time, had to be continually renewed until the full width—22 ft. 7 in.—was thrown open.

This work has now been completed for 2½ years, and still shows an excellent surface. It is, of course, wearing, as is only natural under such heavy traffic, but it is wearing as a granite stone would wear, and there is no sign of any breaking up. The unprotected concrete is carried right up to the tram rails and is standing well and maintaining a good surface along the rails, where the road surface is so difficult to maintain.

After seeing the results of twelve months' traffic over the bridge, the Victoria Bridge Board expressed its satisfaction, and decided to complete the work by concreting the up-stream side of the bridge, and the City Council were again asked to carry out the work.

The second half of the bridge was surfaced with a granite concrete, and the difference in the two wearing surfaces is clearly marked in colour, the granite being lighter than the gravel. As far as the wearing qualities are concerned, they appear so far to be almost equal. The granite surface is taking the bulk of the slow, heavy traffic, and the gravel surface the fast and motor traffic.

A census of traffic on the down-stream half of the bridge was taken on July 24th, 25th, and 26th, 1922, between the hours of 6.30 a.m. and 6.50 p.m., with the following results:—July 24th, 8,388 tons (wet day); July 25th, 9,567 tons; July 26th, 11,223 tons, or a daily average of 9,725 tons, exclusive of tramcars. This represents a traffic of approximately 587,000 tons per yd. width per annum, which is distinctly heavy.
The work generally was carried out in a similar manner to that done twelve months previously on the down-stream half of the bridge, except that in this case the granite aggregate contained a small percentage of granite dust. The dust was rejected in the first concreting of the bridge for the reason that the stone obtainable at the time was from a waste heap of spalls resulting from working kerb and building stone. A percentage of dirt in the dust was unavoidable, so it was rejected.

While these works in concrete road building were going on the City Council were deliberating on a policy of road-making for heavy-trafficked streets, as the maintenance of city streets where traffic was heavy was proving very costly, and ultimately decided in favour of concrete, as on figures provided by the Engineer it proved to be the cheapest road, taking into consideration the period of its life, annual upkeep, interest, and redemption.

With the policy of concrete road building established, abrasion tests were made at the university to test the wearing qualities of granite, gravel, and basalt in different mixtures of cement. Nine 3-in. cubes were prepared, three each of granite, gravel, and basalt, in mixtures of 2 to 1, 2 1/4 to 1, and 3 to 1. The tests were made with sand blasts, three surfaces of the cube being subjected to the blast in each case. The tests showed that in the case of basalt and granite the 3 to 1 gave slightly better results than the 2 to 1, and while there was very little difference in the wearing qualities of the granite and gravel the basalt was distinctly inferior. It was noticed, however, that the granite wore to a more even surface than the gravel.

Queen Street, Roma Street and George Street.—The first contract for concrete road building in Brisbane was let in December, 1921, and comprised nearly 40,000 sq. yds. Work was commenced in March, 1922, and finished in October. The whole of this concrete was laid in two-coat work. The reasons for adopting two-coat work were as follows:—(1) The wearing surface was going to be asked to stand up to heavy steel-tyred traffic, and would require to be composed of the best road material available. (2) The road surface which would have to stand the shocks and blows from heavy loads and horses' hoofs, would require a richer mix than the lower portion of the slab. For these reasons it was considered that the wearing surface should be made with a richer mix and
of tougher materials than would suffice for the base coat. It was further submitted that when the surface coat ultimately wears away the pavement can be sheeted with a 2-in. coat of sheet asphalt or asphalitic concrete.

A good deal of comment and criticism have been made of the fact that the concreted surface has not been given a paint coat of tar or bitumen, as is very frequently done in other places. The answers to this are that the wearing surface has been made sufficiently tough to withstand the traffic without any protecting pad; that a paint coat will wear off in patches and soon become unsightly; that the cost of maintenance in keeping the concrete covered with bitumen and sand will be greater than the wear on the unprotected concrete; the nuisance of tarring and sanding in busy streets will be avoided; that the dust nuisance will be less. Criticism has also been made of the position of the reinforcement, namely, 2 in. below the upper surface, in that it will not help the slab with the under beam action in spanning over soft places. There should not be any occasion for beam action in a concrete road, as the subgrade should be well rolled and consolidated, the concrete being a surfacing layer only, bearing evenly on the subgrade, but if the subgrade fails, and deflection occurs, producing tensile stresses on the under surface of the concrete, then, of course, the under surface of the concrete should be reinforced. The primary object of the reinforcement is to take up the stresses from expansion and contraction under varying temperatures, and as the variations of temperature will be much greater on the upper surface the reinforcement should be near the upper surface. Should the lower reinforcement be necessary it should be accompanied by an upper reinforcement.

Newcastle.—Mr. J. F. Shine, City Engineer of Newcastle, writing to the Sydney Herald in July, 1922, said:—“I have an example in practice . . . in Hunter Street, Newcastle. This street is now after nearly three years of wear, without cracks in any of 300 slabs, except in two instances, for which causes can be found other than wear and tear. The cost of maintenance, including surfacing with bitumen is under 4d. per square yard annually. I have just completed a further section of 8-in. concrete roadway in Darby-street at a cost of 16s. 8d. per square yard, including excavation, and contend that whilst this price can be maintained, this is the roadway for the main streets of my city.”