Early concrete roads in Edinburgh

by R. A. Paxton

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THE modern practice of using hydraulic cement to bind materials in carriageway construction developed progressively, albeit spasmodically, from its first significant usage in the foundation of a 1½-mile improvement of the Holyhead Road at Highgate Archway under Telford's general direction in 1828-9 to its extensive use today. In 1972 some 25% of all major British roads under construction had a concrete running surface and a further 25% had cemented material within the structure of the pavement. A necessary preliminary to this development was the considerable improvement in the quality of cement which occurred with the advent of Portland cement and its establishment in use particularly from about 1851 onwards.

Before the mid-19th century weak concrete made with natural water-limes or Roman cement was used in some British carriageway foundations with varying degrees of success. An interesting early example in Scotland occurred at Dean Bridge, Edinburgh. In designing this bridge in 1829 Telford proposed to incorporate a 4 in. layer of concrete under the hand pitching (Figure 1). From the evidence of a recent trial hole (Figure 2) it is reasonable to assume that his original roadway design was varied, probably for reasons of economy, to the early construction shown in Figure 2 when the carriageway was formed in 1832.

The layer of weak concrete* under the water-bound macadam seems to have had a dual function, namely, load-spreading, but primarily the inhibition of water penetration into the hollow spandrels beneath.

The period from about 1820 until the mid-century can be considered as the heyday of the water-bound macadam road. "Macadamized" roads, as they were known, became established nationally and in towns often took precedence over paved causeways for both renewal work and new construction.†

The macadamizing of roads, before the development of tarmacadam, did not prove to be a complete success. Although such roads were quieter in use and more economical initially than paved roads, they required frequent attention to maintain in good condition. By mid-Victorian times much of the great mileage of macadam roads throughout the country was in a dusty, uneven and often dangerous state. In 1870 a civil engineer wrote graphically of ". . . the miseries of macadamized streets. . . . Vehicles rush through a sea of mud and slush, bespattering passerby and defacing the adjoining houses and shops, the very foot-pavements are bestrewed with mud. In dry weather, when the streets are watered to allay the dust and prevent the surface breaking up, almost the same inconveniences are experienced; so that, as a general rule, the streets in a large town are almost always in a muddy condition."

Forward-thinking engineers and surveyors regarded the shortcomings of macadamized roads as a challenge and recommendations for harnessing concrete to the improvement of Edinburgh carriageways were made at least as early as 1857. In a report of that year to the City of Edinburgh Paving Board by W. A. Jardine, Engineer, reference is made to "macadamizing being now an exception to the general rule" for principal streets and to setts being laid on concrete instead of on a sand bed as had been the usual practice. He refers to Leith Street (which adjoins Princes Street), being "in very

*An X-ray spectrometry analysis of this concrete by Edinburgh University was as follows:

CaO	5·65
K_2O	0·44
Fe_2O_3	2·50
TiO_2	0·26
SiO_2	85·6
Al_2O_3	3·8
MgO	0·6
	98·85

†In Edinburgh in 1828 approximately 60% of the 13¼ miles of roads of the Middle District Trust were macadam and 40% causeway. By 1882, 36% of the 81½ miles of City Roads were macadam, 62% causeway (including roads with concrete foundations) and 1% concrete.

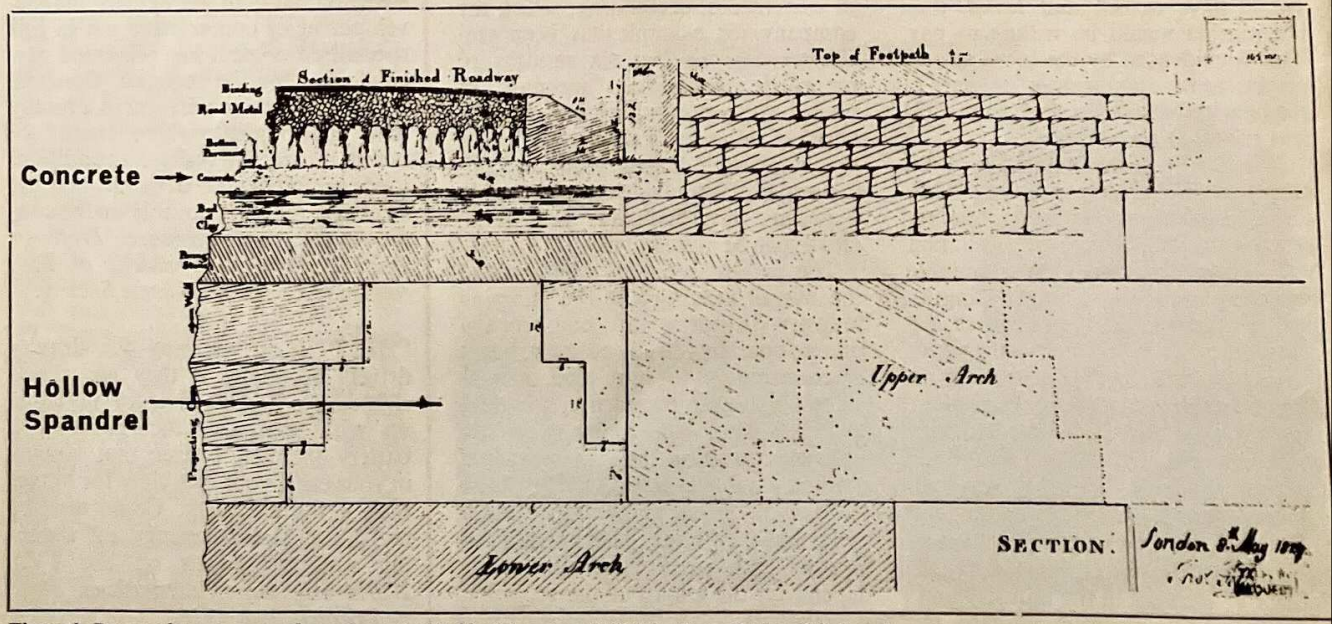

Figure 1. *Proposed cross-section from an original Telford drawing of 1829 for Dean Bridge, Edinburgh.*

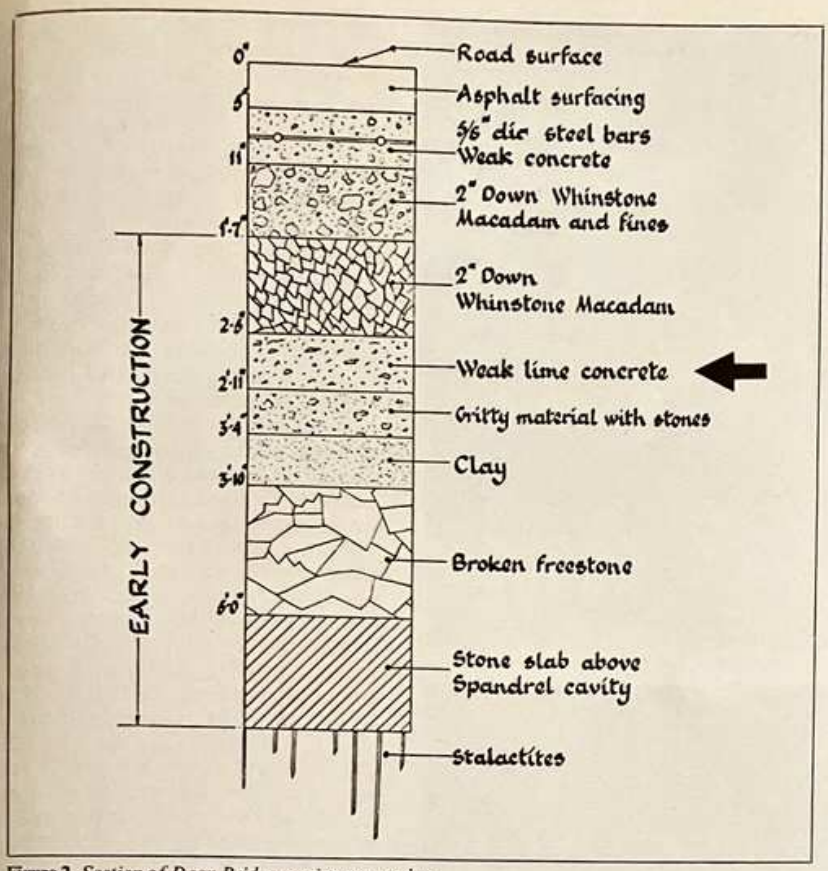

Figure 2. *Section of Dean Bridge carriageway today.*

Figure 3. *Concrete usage at George IV Bridge, Edinburgh—1866. A contemporary record of costs incurred in Mitchell's experimental use of Portland cement concrete both as a sett causeway foundation (No. I) and running surface (No. II). The Portland cement cost about £2·60 per ton and was obtained from Hilton & Co. of London. It was shipped to Leith for 10/- per ton. Broken whinstone aggregate was obtained locally at 6/- per cu. yd. and dressed granite setts from Aberdeen at 24/- per ton. The granite causeway laid on 3 in concrete cost 18·94 shillings per sq. yd. (note the decimals!) and the 6 in thick concrete carriageway 8·047 shillings per sq. yd. (Photograph by courtesy of the Royal Scottish Museum).*

bad order . . . the stones in many places not more than 3 in deep . . . should be lifted and re-causewayed . . . the traffic on it being probably one of the greatest and heaviest in Edinburgh. Were the street laid with 5 in dressed Ratho stone upon a six-inch bottom of concrete the cost is estimated to be about £760. . . . If the concrete bottom were put in 9 in thick —and which additional thickness it is thought would be an ultimate economy —the Ratho causeway would cost about £831.12s." (about 6s. per sq yd).

Whether Jardine's recommendations were put into effect is not known to the author but important pioneering work on the application of concrete to carriageway construction was carried out in the city in 1866. This project consisted of the experimental application of Portland cement concrete to both sett causeway foundations and top surfacing. Areas of each type of construction measuring 750 sq yd were laid down in the heavily-trafficked carriageway of George IV Bridge (Figure 3). The work was executed by

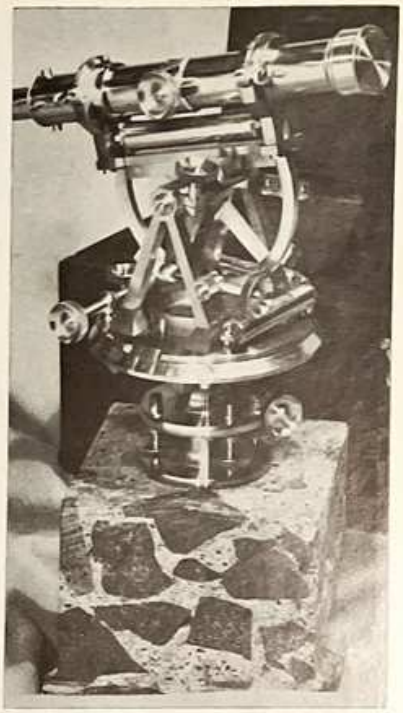

Figure 4. *Specimen of early cement grouted macadam concrete—1878. The concrete was formed on a blinded and rolled stone bottoming 6 in thick as follows: A 4½ in thick layer of 1½ in whin road metal was spread uniformly over the bottoming and grouted with a mixture of fine gravel riddled out of Fisherrow gravel and Robin & Co's best (Portland cement). The cement used was to be capable of sustaining a tensile strain of 600 lb on the superficial area of 2½ in of the standard test block after being immersed 7 days in water. The grout was mixed in a patent steam mixing machine and then spread, beaten and "equalised" into the road surface " in a most careful and tradesmanlike manner." The 5 in cradle theodolite in brass and made by Adie & Son of Edinburgh c. 1870 was used by the Burgh Engineer's staff. (Photograph by courtesy of the Royal Scottish Museum).*

the City Road Trust to the directions of Joseph Mitchell, a leading Scottish road engineer and former pupil and assistant of Telford. Both experimental sections of road were successful and Mitchell published an account of his "New mode of constructing the surface of streets" which included specifications.

Although Mitchell's concept of smooth, hard, dust-free concrete carriageway surfaces, facilitating traction, and with low maintenance costs, was not realised on a significant national scale until comparatively recent times, he did live to see the widespread adoption of Portland cement concrete as a foundation for sett pavements, a practice undoubtedly encouraged by his efforts.

Mitchell also attempted to promote the concrete road as an alternative to tramways, which he considered "wholly inapplicable to the narrow and overcrowded thoroughfares of London, where, among other inconveniences, they will seriously impede

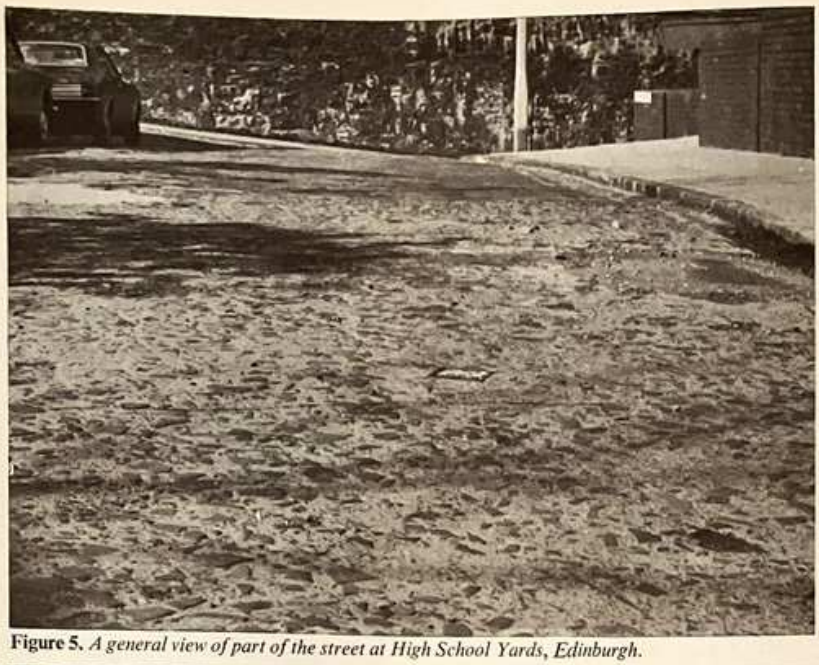

Figure 5. *A general view of part of the street at High School Yards, Edinburgh.*

Figure 6. *Close up of the concrete surface at High School Yards.*

access to our shops and warehouses." He considered that they would interfere with the practical working of traffic by forcing the general travelling on the remaining space on each side. . . . "The object of a tramway is to furnish a smooth and equable surface for the traction of vehicles. I think a well-made concrete road will effect that purpose more thoroughly. It will not obstruct traffic in any part of the thoroughfare. The traction is half that now required on the best macadamized road on a dry day. It is free from mud and dust in all weather. And, if necessary, it may be washed with the water-hose every morning, thereby purifying and refreshing the air in our thoroughfares. . . ."

Mitchell's efforts to promote the concrete road in London were unsuccessful, but his section of four-lane concrete carriageway at George IV Bridge represents a landmark in the evolution of the modern concrete road. Three years after its construction, the Chairman of the City Road Trust referred to its continuing good state despite some uneven "joinings". He commented that the road "is as good today as it was when first laid, excepting at one or two spots which can easily be repaired; and I do not think it has lost above a quarter of an inch by friction over the general surface. Its freedom from dust in summer, and from mire in winter is a great recommendation to it, and carriages running over it produce no more noise than over a well-macadamized road in perfect order. Its original cost is not more than causeway with Ratho stone . . . and I am satisfied it will last double the time . . . some device will, I doubt not, be found for lessening the trouble in getting at gas and water pipes and drains. . . ." He urged the Board to carry out further trials of Mitchell's concrete. The road lasted nearly 40 years.

It can be argued from a modern standpoint that Mitchell under-estimated the problem of achieving satisfactory reinstatement of concrete roads following drainage and public utilities work, but he weighed this drawback, which was of less magnitude before the general introduction of electricity-based services, against the now almost taken-for-granted desiderata of smooth, dustless and virtually noise-free road surfaces. Mitchell evidently convinced the local surveyors on this point, as from 1868 to 1910 concrete carriageway totalling 5½ miles in length was laid in over one hundred Edinburgh and Leith streets, but its use was confined mainly to local access roads. To place this figure in context, it should be mentioned that during the same period about ten times this mileage of sett causeway was laid, much of it on tramway routes and founded on Portland cement concrete.

The method of mixing the concrete in some of the early concrete roads differs from Mitchell's mode as published, in that the open-graded whinstone aggregate was grouted in situ and not mixed up thoroughly with the other ingredients prior to placing. The specimen cube (Figure 4) which is of concrete in this category was cut recently from West Arthur Place, constructed in 1878. This street no longer exists. Some of the earliest concrete roads including Glengyle Terrace (1872), Gillespie Crescent (1872-3), and Blackwood Crescent (1873) still exist, but their surfaces cannot now be seen as they were overlain with a wearing course of asphalt about twenty years ago. The Edinburgh concrete roads certainly justify Mitchell's forecast of low maintenance costs. The total cost of maintaining Blackwood Crescent from 1873 until 1920 was only £40. One of the later concrete roads, High School Yards, constructed as a Private Street in 1904-5 is still in everyday use (Figures 5 and 6) and has required only minimal maintenance since that time. The engineer responsible for the construction of many of these early concrete roads was David C. Proudfoot, Surveyor to the City Road Trust from 1869 to 1873 and City Road Surveyor from 1878 to 1906.

During and after the Great War, with the rapidly increasing use of tar as an economical road binding material, the practice of constructing new concrete roads and sett causeways in the City declined greatly, but the success of the concrete roads may have influenced the construction in 1916 at Canmore Street, Dunfermline, of one of the earliest reinforced concrete carriageways in Britain. In 1950 the length of concrete roads in Edinburgh totalled nearly six miles, mostly dating from before the First World War. Although much of this mileage is now covered with asphalt, the early concrete still continues to make a useful contribution to the roads of Lothian Region.

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