Chapter Seven

Engineering

7.1 Unmade roads

Robert Russell had located Melbourne's streets by aligning them to the right bank of the Yarra, whilst avoiding as many as possible of the existing shanties (Sub-chapter 1.2). Thus, the streets' initial foundations and drainage were matters determined by providence rather than by engineering skill. Robyn Annear gives a wonderfully evocative descriptions of the outcomes of this happenstance in *Bearbrass: imaginings of early Melbourne*.

Not surprisingly then, the early streets were particularly poor in wet weather.[1] Grant & Serle's description[2] is apt:

> *From the point of disembarkation at Cole's Wharf the traveller had to wade through roads of "a porridge consistency" in winter…. Household and slaughterhouse refuse was dumped promiscuously in the streets.*

[Coles Wharf was on the right bank of the Yarra at the southern end of King St, i. e. downstream of Queens Wharf]. The creek gullies associated with these streets were mentioned in Sub-chapter 1.3. One commentator noted[3] chasms up to 6 m wide and 2.5 m deep in the streets. On 16 October 1839 a child drowned in a waterhole in Collins St,[4] and thereafter there were a number of reported street drownings in Elizabeth St and Swanston St, the last is commonly said[5] to have been in 1858, but an Elizabeth St drowning was reported in 1868 (Figure 7.1).[6]

Figure 7.1 Elizabeth St flood in 1863 *Royal Australian Historical Society*

Beyond the streets of Russell's first township, many roads would have begun as footpaths gradually widened by horses and herds of animals and then by hauled carts and wagons. The removal of tree stumps was a major initial problem and then frequent usage would produce ruts which quickly filled with water, animal excrement and many forms of mud. Workers with picks and shovels could produce local improvements although their efforts were often counter-productive. Later, primitive road graders – sometimes optimistically called road machines – were used to improve the shape of the road. Such problems were universal and have been explored in some detail elsewhere.[7] The need to seek useful creek and river crossings and use of wagons drawn by bullocks had a particularly dramatic effect on the local shape and condition of a road and also on its general location and alignment.

Garryowen[8] described the situation in 1840:

> *As for the thoroughfares (misnamed streets), they were almost indescribable. In the dry season some were in places barely impassable…. During winter, the streets were chains of waterholes, and the traffic had to be suspended in places…. Trees, tree-trunks and stumps were to be found everywhere…. Elizabeth St and Swanston St were shallow gullies.*

A new arrival in 1840 commented that:[9]

> *the crossing over the creek at the corner of Elizabeth and Collins St was a beautiful spot to jump when you are on horseback, and there was nothing to interfere with a good steeplechase down Collins St.*

Throughout 1841 and 1842, Collins St had a hole 2.5 m deep outside Scots Church.[10] In 1841, 15 drays were simultaneously stuck in the mud at one spot in Elizabeth St[11] and the Port Phillip Herald cynically mentioned plans to "*convert the Williams River into a street to be called Elizabeth St*."[12] In 1844, the waterhole at the Collins St / Elizabeth St intersection was said to be deep enough "*to drown a bullock*."[13]

Michael Cannon heads his Chapter on streets in his 1991 Old Melbourne Town book "*When Melbourne's streets looked like porridge.*" The description was taken from a remark by Georgiana McRae in her 1841 diary. Garryowen claimed that a local joke was that ferries and punts should be licensed to operate in Elizabeth St. An 1840s diarist[14] described "*the unpaved roads of Melbourne, famed for gutters that meander from side to side.*"

Little better could have been expected from undrained roads formed from in situ materials.[15] These so-called earth roads had a strong propensity to return to their original condition and any attempt to improve them usually saw the road rapidly become the local drain. To drain the roads and any adjacent properties required the establishment of road levels. For instance, Order 28 (Sub-chapter 1.2) in Clause 6 required the door sill of any building to be one foot above the level of the crown of the street. These levels were often established when the road was effectively unconstructed and undrained, so such subsequent work was often a contentious early issue. It particularly gave rise to much anger from the property owners when a road level was later set above the property level, making the property effectively undrainable.[16] Note: *level* in this context refers to the vertical position of the road surface relative to some horizontal datum.

Slowly, attempts were made to produce a usable street system. An overseer of roads - normally the foreman of a gang of the more recalcitrant convicts - was soon sent to the settlement. Lewis Pedra had supervised convict road gangs in NSW before he was appointed overseer of roads in Melbourne in September 1837.[17] Pedra resigned in March 1839 when he became Clerk of Works for the settlement, later in that year he became a publican. Use of convicts and local prisoners was discussed in Chapter 1.4. Key initial tasks for the convict gangs were felling the remaining trees, removing all tree stumps, filling the stump holes, levelling the road surface and digging drains. Late in 1837 convict labour was used to flatten the intersection of Collins St and Queen St. Convicts also worked on Collins St between 1837 and 1839, on the Collins St / Elizabeth St intersection in 1839,[18] and on Bridge Rd, Richmond, in 1841.[19]

Recall from Sub-chapter 1.3 that a creek ran down Elizabeth St. This made road management in that street particularly difficult. As noted in Sub-chapter 1.4, by 1838 four footbridges had been built across the creek at Flinders Lane, Collins St, Bourke St and Lonsdale St, partly using convict labour. Sheds for the overseer of roads are noted in Russell's map of 1837 (Map 1.1). They sat astride Little Collins St between Spencer St and King St.

By late 1841 the use of convict labour had stopped, due to a shortage of both convicts and money. From that time on, unemployed immigrants were assigned to gangs of road workers, working on roads such as City Rd (route AY3). The practice was still in place in 1855[20] and was used during the 1930s depression to construct parts of the Yarra Boulevards (route AY5). Initially, many of the unemployed migrants had come to Port Phillip under a British Bounty system which funded their travel and ensured them of work and housing until they could find private employment.

In 1838 the NSW Police Act was extended to the Port Phillip District. The Act included powers for removing obstructions and realigning streets.[21] Melbourne streets did not need realignment, but tree stumps and road humps had to be removed (or "grubbed"). The last stump was removed from Bourke St in early 1842, but stumps remained in the lesser streets for another decade.

Much more could have been achieved with adequate resources, but the upstart new town received little assistance from the Sydney bureaucracy. To quote Grant & Serle again:

> *There is little doubt that (Sydney) provided nothing like a fair share of revenue for public works in the Port Phillip District. The first major public work was the massive new gaol which rose (at Pentridge) to dominate the town's northern skyline…. It was commonly asserted that only the drowning of a Governor would move Sydney to fund the urgently needed bridge over the river.*

The roads were also a ready and illegal source of construction material, and were frequently, but surreptitiously, quarried. It was an old European tradition.[22] On the other hand, in 1846 material from the Collins St "cutting" west of Elizabeth St was used to extensively level Elizabeth St.[23] Swanston St was also levelled in 1846.[24] The work could be very labour-intensive - a Central Roads Board contract in 1854 for work on Sydney Rd (route KS7) between Somerton and Kalkallo involved some 800 men.[25]

In the outer suburbs a different set of problems arose. In addition to the matters discussed above, as described in Sub-chapter 2.2, the *section lines* often had large gradients that made them prone to erosion damage by running water, that scourge of all unsurfaced roads.[26] In the Bayside suburbs the problem was sand, which "*dragged at the axles of passing vehicles*". This problem was compounded by the narrow wheels of carts and drays and the pounding hooves of haulage animals and of herds being driven to market. The poor accessibility provided by most roads was a wider concern that was often compounded by the common practice based on ancient law[27] in which travellers faced with impassable conditions simply detoured into the firmer private land adjoining the road reservation. This happened on Sydney Rd in the 1850s.[28] Another practice copied from England was for useful material found in the road reservation to dug up and removed to be used to enhance adjoining properties. Timber cutters dug saw pits in convenient roadways. The author has described[29] such practices in pre-19th century England and Blainey outlines similar behaviours in 19th century Camberwell.[30]

Finally, floods were uncontrolled and they frequently destroyed long lengths of roads and demolished expensive and essential fords and bridges.

7.2 Loosely surfaced roads

(a) Drainage - the essential element in road making

The first step in engineered road-making is to provide adequate drainage and the second step is to use suitable material for the road pavement. This simple approach was first clearly articulated and properly applied by John McAdam in England between 1810 and 1823[31] and had been well publicized in the Colony of New South Wales.[32] Drainage is primarily a matter of having adequate longitudinal drains along either side of the roadway. Unfortunately, if road usage and roadside development precede road making, drainage will often prove difficult and expensive, due mainly to inappropriate property levels. Such difficulties did occur in early Melbourne. In a retrospective review, Hoddle wrote[33] "*The Melbourne Macadamites had forgotten to make the necessary drains*." The drainage problem was compounded by citizens continually pumping groundwater from undrained cellars into the open street drains. The effect of these two issues was to linger on for many decades.

Brick drains constructed along Collins St were placed at the wrong level and had to be removed in 1841.[34] After the Melbourne City Council was formed in 1842, it appointed William Howe as Town Surveyor (engineer). His first tasks focused on Collins St and on draining Swanston St directly into the Yarra. In 1844 he began a controversial scheme to drain Elizabeth St into the Yarra.[35] A similar drain in Flinders St was delayed when hard rock was encountered. Later in 1844, tenders were called to "*impound the Elizabeth St watercourse*."[36] One of the solutions involved a "floating drain", a concept that created continual local mirth.[37] Formal gutters were first used in 1846.[38] Nevertheless, Kelly tells[39] of seeing a horse drown at the Elizabeth St / Bourke St intersection in the 1850s. In the 1850s and 1860s it was the practice to construct the four gutters across an intersection as a first stage in surfacing the entire street.[40]

The drains were inconvenient, dangerous and a threat to citizens' health and property. They not only carried rainwater but also operated as a de facto sewage system. In 1862 the Richmond Council's Health Officer publicly claimed that providing kerbs and the associated gutters had significantly reduced the incidence of scarlet fever and other fevers in that suburb.[41] In 1870, the flow of stormwater in an Elizabeth St gutter was sufficient to sweep pedestrians off their feet.[42] In flat areas such as Collingwood many of the street drains simply emptied into large roughly-dug cess pits, which were occasionally and crudely emptied. Underground sewage systems arrived in the 1890s.

Improvements would have come but slowly. Michael Cannon describes the situation in Melbourne in the 1870s:[43]

> *Melbourne was not a comfortable place in which to walk about. Every shower of rain made the unpaved roads muddier and more hazardous, whilst great numbers of horse vehicles churned up mud and manure, into an evil greasy slime......Large open drains down the sides of roads carried away storm water, shop and factory refuse, and excreta.*

The underground drainage of Elizabeth St was not completed until 1883.[44]

(b) McAdam's method for pavement making

Once drainage was addressed, and the road surface was levelled by the removal of obstacles, the next step was typically to import some suitable roadmaking material. Rounded gravels would often be readily available in waterways or alluvial deposits. However, by their nature, layers of such stones were readily disturbed. Crushed or broken stone used for roadmaking was and still is often called *aggregate* or *road metal*. By the time of Melbourne's settlement it was well established that sound, low-cost paving required good stone broken into small pieces and then compacted in place - it would never be achieved by the random dumping of clay, gravel, soft rock or large pieces of hard rock. In particular, it was widely recognised that a course of broken, angular stones provided a far more stable arrangement than did pavements made of rounded gravel.[45] The new approach was epitomized by John McAdam's method which he developed in Britain in about 1810 to 1820.[46] He used 250 mm layers of well-compacted, broken, angular pieces of small stone. The maximum stone size used was under 75 mm. The resulting pavement product was called *macadam*. An early application of the McAdam method had been well applied in Sydney in the decade prior to Melbourne's founding.[47]

Melbourne's underlying silurian rock abraded rapidly under traffic and did not produce good macadam. Nevertheless, the King St "cutting" adjacent to Flagstaff Gardens is a consequence of rock being expediently quarried there to surface the roads to the south. It would have provided only a temporary solution. Worse still, one of Howe's initial tasks as Town Surveyor in 1843 was to add 150 mm of stone to the steep part of Collins St between Queen St and Elizabeth St.[48] An 1843 newspaper report suggests that the material being used contained water-sensitive clay. The pavement predictably failed after the first rainstorm.[49]

The lessons were apparently well learnt. The first macadam road in Melbourne was probably part of Heidelberg Rd (route PL6), as there are reports[50] of the method being used on the road between 1842 and 1848. Indeed, Mrs Charles Perry, the wife of Melbourne's first Bishop recorded[51][52] that just to the east of the Merri Creek crossing:

> *Here and there were neatly piled heaps of broken stone, just as you see in England, and at places we found men at work with shovels levelling, filling up holes, etc.*

It would appear that only the first kilometre east of the creek had been "macadamised."

Macadam was applied generally to the streets of central Melbourne in 1846.[53] Thus a common partial paving practice in early Melbourne was to first construct four formed and metalled pedestrian crossings at an intersection, using a 220 mm layer of broken stone.[54] In 1853, an American merchant commented on the "*nice macadamised pavement and footpath between Queens Wharf (Sub-chapter 1.1) and Flinders St*[55]. The application required organisation and competent tradesmen. It was therefore not universally used and commentator Kelly refers[56] to the distinctly non-macadam paving observed in many Melbourne streets in the 1850s:

> *which consisted in peppering the surface with boulders of rock, that seemed to be precious stones, from the step-mother niggardliness with which they were distributed.*

In 1850 the Government in Sydney introduced an Act to "*enforce the paving, flagging, macadamising, levelling, draining and sewering*" of all subdivisional private streets.[57] It was clearly an Act that was honoured more in the breach than the observance and does not appear to have been directly applied in the new Colony. The pace of local improvement was apparently slow. In 1852 Snell commented *"the streets were nearly ankle deep in mud everywhere and the gutters knee deep*".[58] Resident John Buncle described a walk in the street in the 1850s as "*a dip in the colonial mud*."[59]

In 1854 the new Victorian government began applying Antonio Gabrielli's loan money[60] to urban street construction, and significant improvements were soon apparent.[61] The three major recipients of funds to 1856 were King St, Elizabeth St and a group of streets in St Kilda.[62] There was much scandal associated with the priority that councillors gave to the favoured streets.[63] Nevertheless, Attorney-General Henry Chapman remarked in 1863 that the era of macadamisation of Victorian roads from 1854-58 brought "*a change from misery to comfort - a sudden jump from the 18th to the middle of the 19th century*."[64]

Macadam was given a great impetus when good supplies of hard, angular stone became available from basalt quarries in Clifton Hill on the Merri Creek at the end of Ramsden St, just downstream from the Heidelberg Rd bridge (route PL6). The supply was further improved in the early 1860s when the quarry was equipped with steam-powered stone crushers. Mountain[65] suggests that the quarry was not opened until 1876. However, there were two quarries at the site – one run by Collingwood and the other by the City of Melbourne. In 1874 the main quarry was 30 m deep, and it later reached the bottom of the 36 m thick basalt layer. It was closed in 1934 when it was badly flooded, but the other quarry remained in operation until the 1950s.

Most basalts,[66] when crushed, provide stone well-suited for road making as both a foundation course and a surface course. Melbourne has been relatively fortunate in having access to many sources of good basalt. As in Europe, there was some initial reluctance to move from hand-broken to machine-crushed stone but, by the end of the 1860s, this reluctance was swept aside by the cheaper cost and better performance of the crushed product.[67] Further impetus came with the introduction of steam rollers in 1869.

To give perspective to this progress, Cannon refers[68] his readers to the Illustrated Australian News in 1887:

> *It would take a sounding line to discover the precise whereabouts of a crossing at the intersection of Collins and Elizabeth St or in the vicinity of the Town Hall.*

Most of the streets of inner Melbourne were macadamised by the early 1890s.[69] Still, Cannon remarks[70] that "*Melbourne roads were deplorable for much of the (19th) century*".

A popular variation was water-bound macadam in which soil-based binders (usually with a high clay content) were washed into the mix. While damp the binders provided a more cohesive mix and a better traffic surface. However, they were of little added value when conditions were very dry or very wet - indeed in these circumstances they often contributed to the dust or the slime. Thus McAdam had prevented the use of fine material, however he had not seen the "dust" produced by powered stone crushers. When this became available in the mid-1860s, engineers soon came to realise that a stone mix giving a continuous range of inter-filling crusher particles would give the best results.

(c) Early alternative methods of pavement making

The alternative form of construction to macadam was Telford paving, where the road was built from cubical blocks of stone like a horizontal masonry wall.[71] It was relatively expensive, but safe, and placed no reliance on engineering intuition. Telford paving - or "pitching", as it was called - was used in Australia from 1830 to 1930. In 1848 the Melbourne City Council began placing Telford paving at the major intersections and in 1855 the method was more widely applied to Melbourne's streets. It was used on Williamstown Rd (route AY2) in Port Melbourne in the 1890s.[72] A notable later example was its use on Geelong Rd (route GL6) in 1924.

Macadam is cheaper and more effective than pitching but requires better engineering skills. Throughout the world in the 19th century there was contorted argument on the relative value of the two methods.[73] Melbourne's debate was more contorted than most and resulted in an 11-6 vote of Councillors in 1866 demanding that macadam be replaced by Telford construction, more for the purpose of job creation than for efficient use of ratepayers funds.[74] Even Telford paving requires the cubical blocks to be protected from traffic wear (particularly from narrow steel-tyred pre-automotive wheels) by a surface layer of broken stone. This lesson was frequently forgotten by unskilled local authorities (Sub-chapter 3.3). The early CRB annual reports often expressed concern at the lack of local attention devoted to such issues.[75]

A combination of Telford construction topped with a macadam wearing course became popular, and was the preferred method used by the Central Roads Board and then the Board of Lands and Works (Sub-chapter 3.3) in the late 1850s[76]. The approach persisted.[72] Writing in 1908, a prominent Melbourne road engineer said:[77]

The tendency of modern practice is to combine to some extent the methods of McAdam and Telford by laying a bottom course of (Telford paving)…… (Macadam paving) is spread on the (Telford paving).

Whilst macadam was an improvement, it was only an interim solution to a serious problem that the author has previously described:[78]

The stone at the macadam surface was regularly dislodged by the hooves of passing horse traffic and usually replaced by their excreta…. Thus urban macadam surfaces were frequently dusty in summer, muddy in winter, slippery, slimy and malodorous…. The roadway becomes an ocean of mud or a desert of infected dust.

The situation was common at the time in all the world's cities, as they relied on the horse for transport and macadam for pavements.[79] The long-term solution will be discussed in the next Sub-chapter. In the short-term, municipalities began regularly watering their streets to remove winter's slime and suppress summer's dust. Street watering began in Melbourne in 1845. Nevertheless, in 1899 city roads were still being described[80] as "*gluey mires of mud*."

A simple method of road-making in heavily treed areas is corduroy construction in which logs of around 4 m in length are placed transversely across any poor ground – one layer on top of another if necessary - until a usable surface is obtained. The technique was simple but produced a very rough and uneven ride[81]. Chapter 4 noted its use on route DN3&4.

Apart from the practical concerns just discussed, there was a broader user-based need for better road surfaces. In their widely used local textbook on roads the Coanes in the 1927 edition on p3 were listing the following tractive forces needed to pull "a wagon and its contents on a level road at 4 km/h". The wagon had 50 m wide iron tyres.

deep clay	600 lb
50 mm of clay,	500 lb
deep sand	450 lb
muddy road	200 lb
dusty road	100 lb
gravel road	70 lb
macadam,	40 lb
blocks (wood or stone)	30 lb

The 20-fold improvement from worst to best indicates the potential benefits of well-made pavements. That potential would have been obvious but would often have required unrealisable resources.

The first input of engineering skill to the town's bridges occurred in 1844 when David Lennox arrived in Melbourne from Sydney, where he had built many fine bridges.[82] Lennox had trained under Thomas Telford[83] in England. Most immigrant road engineers had gained their experience in Britain, North America or India.

7.3 Sealed and firmly surfaced roads

(a) Stone and steel

Two forms of road surface commonly used in Europe at the time of Australian settlement were cobblestones and stone setts. Cobblestones comprised of pieces of naturally-shaped stone, often water-worn stone taken from river beds, usually at least 150 mm in size and carefully placed to form a tight - if somewhat uneven - surface. Stone setts were carefully-shaped cubical stone blocks, typically with sides 75 mm or more in length (and thus much smaller than the blocks used in the Telford paving method discussed in Sub-Chapter 7.2c above). They had to be placed on a carefully prepared bedding layer up to 200 mm thick.[84] Cobblestones were rarely used in Melbourne as they were relatively slippery, noisy and expensive under local conditions and when used by "modern" horse traffic.[85] Some western plain roads such as Taylors Rd were initially paved with cobblestones from the surrounding paddocks which had been strewn with basalt cobbles. Basaltic setts were used in Flinders St in the 1880s but rutted excessively under the steel-tyred and rigid wheels then in use.

More elaborate forms used in Europe used masonry blocks or steel plates for the wheel path. The concept was known as the cartway[86] (or iron way or steel way) and had some imaginative appeal as horses and bullocks could still find some purchase in the ground between the wheel paths. In this context, a number of local councils used a proprietary German product in which preformed steel wheelways with guiding flanges were set on a concrete bed. The result was sometimes called a *plateway*. The system was used on a 15 km stretch Nepean Hwy (route SK3) between Brighton and Moorabbin and in the Moorabbin area in the 1880s. The first (1885) section ran 1.3 km from Asling St to Bay St in Brighton. The cartways linked vegetable farms and their city markets, carrying farm produce to the urban markets and urban "night soil" (human excreta) to the farms.[87] The cost was said to be comparable to the cost of a fully paved road. The work was funded by both the Shire and the Public Works Department in 1884-5. In 1886 the Department funded the extension of the system in the Moorabbin area and to City Rd and Moray St north in South Melbourne. A similar track had earlier been installed in Sydney Rd (route KS7) to aid the transport of bricks from the local brickworks. In 1901 a plateway was installed in Newlands Rd, Coburg.[88]

In their 1927 edition (p21), Coanes downplay the method as having little general use and low added value. Active use of the system stopped in 1930. A remnant of the technique was in use along Centre Dandenong Rd [9s] in the late 1950s. One line of plateway remained in the unsealed road shoulder about a metre from the edge of the bituminous seal and was used by local cyclists.[89] In 1992 it was incorporated into the nature strip outside Capital golf course. It is on the Victorian Heritage Register as item H928.

(b) Timber roads

In Australia the major initial challenge to stone surfaces was wood-block paving. Softwood paving had been used in Europe throughout the nineteenth century but had a poor maintenance record.[90] As a consequence of pioneering work by Melbourne City Engineer Adrien Mountain (Figure 7.2), tar-soaked timber blocks made from Australian hardwoods were found to be far more suitable and for a time had no serious technical competition. The hardwood blocks were first used in a test pavement in Sydney in 1880, and a few months later in Melbourne at the intersection of Collins St and Swanston St. By 1900, all of Melbourne's city streets were paved with about fifty million individual wood blocks,[91] mainly utilising very durable red gum timber. It was by far the most widespread of the paving methods used in Melbourne prior to the First World War. Typically, cubical wood blocks were about the same size as the stone setts and were placed on a concrete base and the surface sealed with tar. The work gained international technical attention[92] and it was observed by a leading local expert that "*The first claim of Melbourne roads to engineering attention overseas was when Mr A. C. Mountain made the world aware of the advantages of Australian hardwood as a surface paving*"[93]. Mountain's efforts established a profitable export market. He later introduced the method of protecting the wood block paving by a thin asphalt surface course[94] and pavements of this type could still be found in Melbourne in the 1990s (e. g. near tram tracks in Spencer St). Timber blocks placed on a reinforced concrete base were still being used for new roads in the 1920s and 1930s - for example, Lonsdale St and Batman Ave were paved in this manner.[95]

Figure 7.2 Adrien Mountain. A detailed account of Mountain's major contributions to paving is available.[96]
City of Sydney archives

From the time of first settlement, wooden beams were also used for foundations in poor ground. The technique was a variant of corduroy construction (Sub-chapter 7.2). When Dandenong Rd (route DN3) was being rebuilt in 1971 near Grange Rd, sawn red gum timbers, 300 by 200 mm, were found laid side by side under one length of road.[97] One common use[98] of timber in poor ground was to provide the walls and floor of a trench in which good pavement material could be placed without fear of dispersal into, or infiltration by, the poor underlying material. It thus played a similar function to a modern sub-base.[99] This would probably have been the method used in the Dandenong Rd application discussed above.

Dressed timber was successfully used for many years for kerbing in urban areas. There was also some use of longitudinal wooden planks for road building.[100] The planks were placed on top of cross timbers and located in the wheel paths in the manner of a railway. Elaborate forms of the method were brought from Canada from 1836 to the mid-1840s as the "farmers' railroad" and enjoyed a short period of popularity.[101] City Rd (route AY3) was a major Melbourne application. Between 1853 and 1857 the Central Roads Board constructed 4 km of plank road on the Geelong Rd (route GL5) in Footscray and 5 km on Mt Alexander Rd (route MM5). Cooper[102] reports papers of the nearby Gardiner District Road Board in the late 1850s stating that " *a scarcity of red gum planking.....led the Board to accept blue gum*." In the 1860s they were still being extensively used in rural areas, and as footpaths in swampy South Melbourne. In service, the planks were slippery and short-lived and the method never fulfilled the promises of its promoters. The obvious variant of placing two wheelpath lines of slabs on macadam - giving a friction surface for hooves - appears to have been little used.[103]

(c) Asphalt

The second widespread new alternative to stone paving was asphalt, which is a mixture of bitumen (or tar) and stone.[104] It was first used in Paris in the early 19th century and in London in abortive trials in 1869.[105] Slightly more success had been experienced in Paris followed by Washington in the 1870s and 1880s and finally in London trials in 1895.[106] Asphalt was being imported into Australia by 1890.[107] Brown-May 1998 reports an unreferenced asphalt trial in Elizabeth St in 1870. This seems inconsistent with the dates in Chapter 7 of Lay 1992. Popular brands were Trinidad and Neuchâtel - the names referring to the source of the asphalt. Asphalt paving was first introduced into

Melbourne when Trinidad asphalt was used in 1894 to pave a private lane off Little Collins St.[108] It soon became a key competitor for block paving (see above), although many claimed that it was too slippery for iron-shod horses. Be that as it may, it was the right product for the new pneumatic tyres that were in use from the 1890s.[109] Later, pure bitumen was imported - often from Mexico - and mixed with local stones.

When tar, wood pitch and bitumen[110] became available as by-products of other processes, people began to consider their use for roadmaking. Tar is a by-product derived from coal and was readily available as a gasworks residue. Wood pitch is produced as sap or by burning timber. Bitumen is a by-product of petroleum refining.[111] These products are broadly similar, although tar is potentially carcinogenic.[112] They could be used to produce asphalt, initially by a bridging technique known as tar macadam (or tarmac). In this method, tar was worked into the interstices of a macadam pavement.[113] The method - known as penetration macadam - had been used in Europe since the 1840s.[114] It was first used in Melbourne in 1867[115] and then in Collingwood. It was more extensively trialled in 1878 on Collins St between Elizabeth St and Swanston St.[116]

When mechanical mixers became available at the turn of the twentieth century, they were used to produce modern asphalt by pre-mixing the tar and stones. The technology spread slowly. However, in 1910 Melbourne City Council made the landmark decision[117] that it would henceforth favour rolled (or compressed) asphalt[118] over wood blocks. There were two reasons: the products were now of equal price, and hardwood blocks were becoming harder to obtain. Bitumen was not widely used in Australia as a substitute for tar until after the First World War. The first CRB Annual Report (p59) remarked "In America a residual from the distillation of crude petroleum (asphaltum) is used in the same way as tar." The Council decision did not last as long as the pavements for timber blocks placed on a reinforced concrete base were still being used for new roads in the 1920s - for example, Lonsdale St and Batman Ave were paved in this manner.[119]

The CRB conducted new trials of penetration macadam on Geelong Rd (route GL6) in Footscray and Braybrook in 1925, using emulsified bitumen that could be used without heating. The product remained popular through the 1920s. The technique used was to place a full course of open graded stone - the stones had a maximum dimension of 75 mm. Emulsified bitumen was then poured or sprayed onto the surface, penetrating the course. Finer stone was then rolled into the interstices in the surface layer. Finally, the surface was sprayed and sealed with bitumen. As larger mechanical mixing plant became available, use of the penetration method declined and had disappeared from CRB specifications by 1932.

The CRB also tested asphalt and concrete on Dandenong Rd (route DN3) in Oakleigh between 1921 and 1925. It used as its key test pavement 5 test strips each 120 m long and 5.5 m wide.[120] The tests demonstrated that concrete (see (e) below) could provide a satisfactory surface, but that care was needed with joints and with pavement edge thicknesses. More importantly, the tests convinced the CRB engineers that asphalt was preferable to concrete as it could be more readily placed over macadam or Telford basecourses.[121] The procedures used were based on practice in Maryland, USA, using 900 mm wide concrete shoulders for night-time delineation. The trial continued to be monitored and was further reported on a decade later in 1936.[122] The behaviour remained good, although wheelpath wear had reached a relatively high (by modern standards) rut depth of 17 mm. In 1946 the Princes Hwy West (route GL6) near Kororoit Creek was paved with 50 mm of asphalt placed over macadam.[123]

(d) Spray and chip seals

The spray-and-chip-seal method is an effective and relatively low-cost way of treating road surfaces. It involves spraying bitumen onto the well-rolled stone surface of a previously untreated road. The initial stone surface is typically a layer of stone pieces forming a *macadam* layer (Sub-chapter 7.2). The individual pieces of broken stone are often called *chips*. A thin protective coating of stones is then spread over the still-sticky sprayed surface and rolled into place. This produces a waterproof, stable surface, commonly called a sealed road, as the spray seals the pre-existing road surface. It is predominantly used for rural roads as it can be noisy under traffic and requires regular maintenance, but it would have been the first engineered surface applied to many of Melbourne's roads and streets. It was invented in Monte Carlo in 1902[124] and – after the First World War – came to be widely applied in Victoria, initially using tar as the adhesive spray.[125] The streets of Brunswick, for example, were first "sealed" in the late 1920s.[126] The CRB began major spraying work in 1924, when new mechanised equipment became available. In 1925-26 it sealed a remarkable 280 km of road at a cost of £143/km.

(e) Concrete roads

Pure concrete roads have never achieved much popularity or usage in Melbourne, although they have usually been reasonably cost-competitive. They began as a base for timber block or asphalt paving. However, as the blocks became more expensive, the concrete came to be increasingly used for the entire pavement structure.[127] Concrete pavements grew in popularity after mechanical concrete mixers became available at the turn of the century and reached a peak in the years following the First World War when the concrete was used by Councils as both the structural course - carrying timber blocks or asphalt - and as the traffic (or wearing) course.[128]

From its inception in 1913, the CRB had favoured using concrete roads. However, in 1919 following an overseas visit by a staff member, it decided that bituminous surface treatments were more appropriate.[129] Nevertheless, as noted in (c) above, a length of concrete pavement was included in the Oakleigh trials in the early 1920s.[130]

In order to compare the performance of unreinforced and steel reinforced concrete slabs, in 1914-6 local government engineer A. S. Aughtie placed a test pavement 150 mm thick on the west side of St Kilda Rd (route SK2). Subsequently, concrete with steel mesh reinforcement to control cracking was used in full-scale paving on St Kilda Rd in 1921.[131] Further such roads were constructed in suburban Richmond. The first major reinforced concrete roads were probably Bridge Rd (route TW5) and Swan St (route CT5) built by J. Noble Anderson when City Engineer of Richmond in the early 1920s.[132] He used a cement-rich mix to produce a 160 mm slab. The reinforcement was 6 mm diameter rod in a 200 mm grid, with extra steel along the slab edges.[133] A major piece of concrete road was constructed on Princes Hwy East (route DN3) between Grange Rd and Poath Rd in Caulfield. As noted in the discussion of that route, there was some poor ground in this area. In such circumstances, the concrete road lasted well, until replaced during reconstruction in 1971.[134]

In the early 1920s a Sandringham City Engineer, W. Sunderland, developed the concrete equivalent of penetration macadam and had considerable success with this "cement penetration" technique in the Aspendale - Carrum area over the next decade. The pavement was normally placed in two layers with a total thickness of about 200 mm. The technique was also used on some major roads, such as Anderson Rd (route GL9) in 1931.[135]

An alternative method used spasmodically from 1934 to the present in the sandy south-eastern suburbs has been roller-compacted concrete. In this technique, relatively stiff concrete is rolled into place like asphalt. The rolling reduces air voids in the concrete mix. The surface is usually rough and requires an asphalt finishing course. The first major application was on Beach Rd (route AY4) in Mordialloc in 1934. The method had apparently been "provisionally patented by two members of the CRB staff some years ago" (1935).[136]

A post Second World War breakthrough occurred with the use in 1964 of a concrete pavement in the reconstruction of Victoria Pde in East Melbourne. One of the main problems with concrete roads has been that they make it very difficult to access any services placed below the road. The concrete industry for most of the 20th century has claimed unreasonable bias amongst Melbourne's roadmakers. And yet your unbiased author is one of a large group of Melbourne road engineers who strongly but subconsciously still prefers bituminous asphalt over cementitious concrete. Both use the same stone base - in one the glue is bitumen and in the other it is cement mortar.

(f) Paths

The first footpath was probably provided in 1841.[137] By the late 1840s most of the streets of Melbourne had gravel footpaths that were as popular with horse riders as they were with pedestrians. In the 1850s, despite the availability of good local stone, loan money and property-owner subsidies were used to important heavy flagstones from Scotland to construct the footpath in front of the subsidiser's property.[138] Occasionally, the flagstones came as ships' ballast. Of course, formal paths could not be placed until property levels were established. It was noted in Sub-chapter 7.2 that this was no simple task. In 1852 a few footpaths began to be delineated by kerbstones. Serious footpath construction began in the early 1870s and by the 1880s inner Melbourne's footpaths were all paved.[139]

Poor drainage (Sub-chapter 7.2) meant that in wet weather streets often became impassable for pedestrians. Horses and animal-drawn vehicles "*churned up mud and manure into an evil, greasy slime. Large open drains carried a mix of stormwater, refuse and excreta*."[140] Drainage was expensive and in the early 1870s there were still many deep open gutters spanned by pedestrian footbridges (Figure 7.3). In 1880 the Australian Club in William St asked for its footbridge to be enlarged as the current one was unsuitable "*for a building of the magnitude of the Club*."[141] The wider solution to these problems required the provision of underground sewerage.

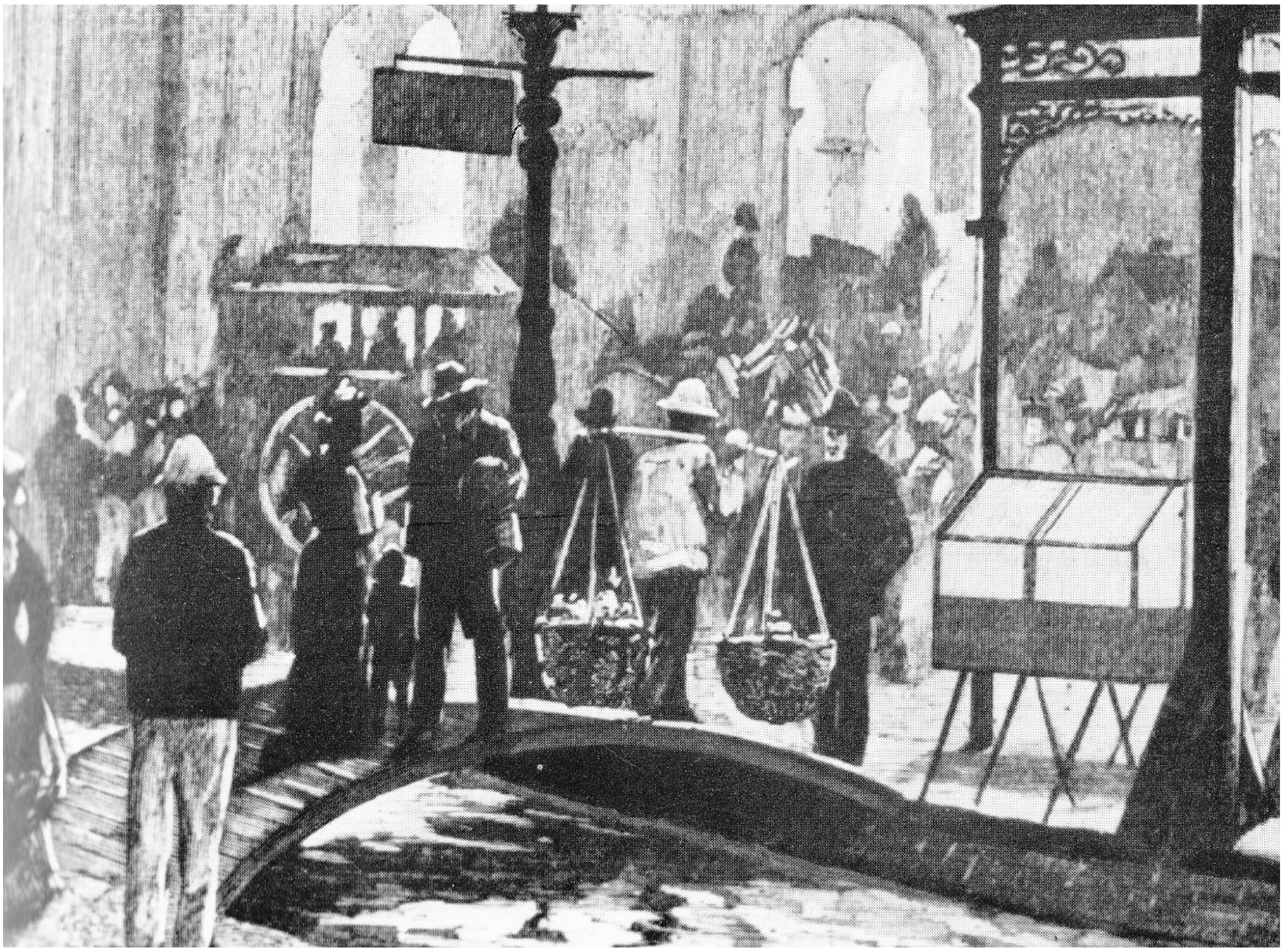

Figure 7.3 Street gutter "bridge" at the southeast corner of Elizabeth and Bourke Streets in the 1870s. The Post Office is in the background. *Melbourne University Library*.

The first street lighting was the result of a regulation in the early 1840s requiring hotels to light their public footpath. In 1846 the Council supplemented this with further gas lighting at critical points.[142] Extensive gas street lighting was introduced in early 1856.[143]

(g) In summary

The engineering of Melbourne's roads did not provide many major challenges or produce any unique solutions. The technology used is well documented.[144] There were occasional local shortages of good road-making stone, and in the north-western area some of the basalts degrade into expansive clays,[145] which make it impossible to maintain a level road surface without taking elaborate and relatively expensive measures.

Thus, the development of Melbourne's roads depended on finance rather than engineering. Further, the roads were not that difficult to build and, by world standards, the bridge needs were infrequent and undemanding. The problem was that the low-density distribution of the taxpaying population meant that the amount of street paving per person was abnormally high. Good paving was expensive and slow to install. Nevertheless, when it finally arrived, Melbourne's fine new paving, be it blocks or asphalt, combined with the advancing provision of underground stormwater drains and a separate sewerage system, saw the dramatic transformation of the city. The pity was that the provision of these three expensive infrastructure systems could not keep pace with the rapid growth of the city. Indeed, that landmark event did not occur until well into the 1970s.

7.4 Maintenance

Today, most metropolitan roads are subjected to systematic maintenance before major degradation has occurred. It has not always been thus. The two World Wars had a major impact on Australia's roads. The end of the First World War was the beginning of the use of the motor truck and the common car.[146] The roads lacked the strength and the capacity to handle these two new devices and the community lacked the resources to strengthen and extend the roads. Many roads failed under the load. The road system was still recovering when resources were diverted to meet the needs of the Second World War.

Like most Australian roads, Melbourne's road pavements since the 1920s have been under- rather than over-engineered.[147] They therefore need careful attention to maintenance if they were to remain intact. During the Second World War, that maintenance disappeared and the already over-used roads often literally fell to pieces. This was the period of the "heartbreak" roads and streets, which required massive capital expenditures over the next thirty years to rectify.[148]

Notes for Chapter 7

1 Brown-May 1998, p32
2 Grant & Serle 1957, p8
3 Griffith 1845, p5
4 Port Phillip Herald, 30 June 1840.
5 Lay 1984, p10, and Barrett 1979, p17
6 Argus, 6 April 1868, p5
7 Lay et al 2020, Chapters 3 & 7
8 Finn, p108-9
9 Davison & May, p7
10 Port Phillip Herald, 13 July 1841 and 29 March 1842.
11 loc cit, 2 July 1841
12 loc cit, 5 February 1841, p3
13 loc cit, 9 Jan 1844, p2
14 Lay 1984, p9
15 Lay 1992, p65-69
16 Cannon 1984, p187
17 Tibbits et al, p25.
18 Cannon 1984, p206
19 McMillan 1993
20 Argus, 17-8-1855, p5
21 Barrett 1979, p17
22 Port Phillip Herald, 18 October 1844 & Lay 1992, p66.
23 loc cit, 2 Feb 1846, p2
24 loc cit, August 1846
25 Payne 1975, p18
26 Lay 2009, Section 26.2.3
27 Lay 1992, p64-5
28 Payne 1975, p18.
29 Lay et al 2020, Chapter 7
30 Blainey 1980, p39
31 Lay 1992, p77
32 Lay 1984, p16
33 Colville 204, p180
34 Cannon 1991, p26
35 Cannon 1991, p128

[36] Port Phillip Herald, 31 May 1844.
[37] e. g. Port Phillip Herald, 20 Jan 1846, p2
[38] Port Phillip Herald, 24 March 1846, p4
[39] Grant and Searle, p98
[40] Cannon 1993, p136
[41] Argus, 25 April 1962, p5
[42] Age, 4 Jan 1870, p5
[43] Cannon 1966, p8
[44] loc cit, p136
[45] Lay 1992, p77
[46] Lay et al 2020
[47] Lay 1984, p16
[48] Cannon 1991, p127
[49] Port Phillip Herald, 29 August 1843
[50] Garden 1972, pp77-81
[51] Grant and Serle 1957, p59
[52] Kenyon 1934, p75
[53] Port Phillip Herald, 2 Feb 1846, p2
[54] See Mason's map of 1855.
[55] Cannon 1993, p31
[56] Grant and Serle 1957, p98
[57] Cannon 1993, p131
[58] Snell 1988, p321
[59] Buncle, J. 1888
[60] Cannon 1975, p48
[61] Dunstan, p147
[62] Cannon 1993, p135
[63] loc cit, p136
[64] Serle 1963, p235
[65] Mountain 1894, p6-7
[66] Lay 2009, Section 8.5.1
[67] Smith 1874
[68] Cannon 1975, p50
[69] Brown-May 1998, p34
[70] Cannon 1975, p48
[71] Lay 2009, Section 3.3.4
[72] Champion
[73] See Lay 1992, p78-81
[74] The debate is nicely recorded in Argus, 24 April 1866, p6
[75] e.g. CRB Annual Report 1 (1914), p41-3 & 3 (1916), p9-10.
[76] Snell 1988, p98
[77] Coanes 1908, p153
[78] Lay 1992, p204
[79] Lay 1992, Chps 5 & 7
[79] Graham Gilpin, private communication, 3/2001.
[80] loc cit, p51
[81] Lay 1992, p207
[82] Lay 1984, p5
[83] Lay, 1992, p74-5
[84] Lay 1992, p223-6
[85] Coanes 1908, p242
[86] loc cit, p227
[87] loc cit, p250
[88] Burchell 2004
[89] Graham Gilpin, private communication, 3/2001.
[90] Lay 1992, p226-7
[91] Lewis 1995, p76
[92] Partly via Mountain 1887-8.

[93] Anderson 1934, p360
[94] Anderson 1934, p360; Mountain 1894 & 1904
[95] Lewis 1988, p92
[96] Lay et al 2020, Chapter 12
[97] Settlers 1971
[98] Coanes 1908, p245
[99] Lay 2009, Sections 2.2 & 11.1.2
[100] Lay 1992, p206
[101] Lay 1992, p207, Amsinck 1856 and McCreadie 1856
[102] Cooper 1935, p49
[103] Argus, 16 April 1857, p7
[104] Lay 1992, Chap 7
[105] Coanes 1908, p215
[106] loc cit, p235
[107] loc cit, p232
[108] Mountain 1903, p13
[109] Lay 1992, p147
[110] Lay 1992, p217.
[111] Lay 2009, Section 8.7
[112] Lay 2009, Chapter 8
[113] Coanes 1908, p218
[114] Lay 1992, p218
[115] Argus, 22 October 1867, p5
[116] Age, 9 Jam 1878, p3
[117] Argus, 4 October 1910, p5
[118] Lay 1992, p211
[119] Lewis 1988, p92
[120] CRB AR24-25, p29-38; AR25-26, p12-15; Better Rds 1(8), 20 Nov
[121] CRB AR25-26, p12
[122] CRB AR35-36, p42
[123] Darwin 1946
[124] Lay 1992, p246
[125] Coanes 1908, p204
[126] Folk-Scolaro 1999, p10
[127] Lewis 1988, p90
[128] Gill 1984 & Lay 2009, Chap 11
[129] CRB AR 1919, p4
[130] loc cit 1925, p24
[131] Lewis 1988, p93
[132] Anderson 1934, p360 & Anderson 1923, p21
[133] Lewis 1988, p93
[134] Settlers 1971
[135] Lewis 1988, p95
[136] CRB AR 1935, p87
[137] McGowan 1951, p8
[138] Cannon 1993, p137
[139] Brown-May 1998, p42
[140] Cannon 1966, p8
[141] Brown-May 1998, p33
[142] McGowan 1951, p8
[143] Cannon 1993, p141 & Barrett 1979, Chap 25
[144] Lay 1984 & Lay 2009, Chaps 11 & 12
[145] Lay 2009, Chap 8
[146] Lay 1992, Chap 6
[147] Lay, 1984, p18
[148] Anderson 1994, Chap 9