

7.01 *Early Lime and Cement*

- a. **shell lime and imports**
- b. **rock lime**
- c. **lime burning**
- d. **hydraulic lime and cement**
- e. **mortar and grout**
- f. **stucco**

The nature of early buildings and engineering works in Australia was greatly affected by the location of the raw materials, for where they were lacking it was simply impossible to translate standard British practice onto the colonial scene. It was in fact the very lack of a good hydraulic lime or cement, or indeed a rock lime of any sort, which determined much of the architectural character of our first settlement.

a. shell lime and imports

Neither limestone or chalk was to be found in the vicinity of Sydney Cove,¹ and shells were burnt for lime in the first months of settlement, as they had been in other colonies in North America² and South Africa.³ Governor Phillip is said to have brought a little lime from England to the settlement, but he had to try and obtain more locally even for his own house. 'The Governor', wrote John White, 'notwithstanding that he had collected together all the shells which could be found, for the purpose of obtaining from them the lime necessary to the construction of a house for his own residence, did not procure even a fourth part of the quantity which was wanted.'⁴ Such lime as could be obtained from sea shells at Sydney was in great demand for stuccoing and plastering over the other inferior building materials, and not much was used for mortar or other structural purposes.

To the shortage of good mortar can be attributed the prevalence of single storey buildings in early Sydney, as well as their rapid rate of deterioration. As Phillip said, 'the materials can only be laid in clay, which makes it necessary to give great thickness to the walls, and even then they are not so firm as might be wished.'⁵ Brick walls were built with mortars of clay or loam at Government House, Parramatta, of

¹ Arthur Phillip, *The Voyage of Governor Phillip to Botany Bay* (London 1789), p 145.

² Specifically oyster shells in the case of the New England and Chesapeake Bay colonies: A H Ameri, 'Housing Ideologies in the New England and Chesapeake Bay Colonies, 1650-1700', *Journal of the Society of Architectural Historians*, LVI, 1 (March 1997), p 10. An early example of the use of oyster shell lime mortar was the Apyucxet Trading Post at Bourne, Massachusetts, of 1627: Hugh Morrison, *Early American Architecture from the First Colonial Settlements to the National Period* (New York 1952), p 90.

³ R B Lewcock, *Early Nineteenth Century Architecture in South Africa* (Cape Town 1963), p 278; Brian Kearney, *Architecture in Natal* (Cape Town 1973), p 66.

⁴ John White, *Journal of a Voyage to New South Wales* (London 1790), pp 133-4. For a detailed analysis of the building see Helen Proudfoot, 'The first Government House, Sydney' (mimeographed typescript report to the Premier's Department, NSW, 1983), p 15.

⁵ Phillip, *The Voyage of Governor Phillip*, p 146.

1790, and John Macarthur's Elizabeth Farm of 1793.⁶ Lieutenant-Governor David Collins was particularly unfortunate: due to the lack of lime the house built for him on the western side of the Tank Stream 'gave way with the heavy rains and fell to the ground'. Loam was also used for plastering. The only surviving Victorian example of external loam stucco, according to Hanut Dodd, is that of 'Ercildoune' near Ballarat, of 1859.⁷ Loam was used even more commonly for internal work, as at Robert Hoddle's house in Melbourne of 1838,⁸ and a surviving example is the ceiling of St Andrew's Manse, Port Fairy, of 1856.⁹

As a general rule shells can be easily seen in the mortar of older buildings in coastal and riverine New South Wales. Shell lime was burnt from the piles of oyster shells found in Aboriginal middens all along the coast, and when these were exhausted the bays and inlets were dredged for live oysters.¹⁰ In the 1850s and 1860s the activities of the shell diggers had become a problem in the Sydney region, and were resulting in the depletion of oyster supplies, a problem overcome only when the establishment of railway connections in the 1870s enabled rock lime to be brought from inland.¹¹

At Coal River [Newcastle] the lime was made from oyster shells which, according to W C Wentworth, were found close to the banks of the river 'in beds of amazing size and depth', which some surmised were the results of the perennial feasts of the Aborigines. Wentworth himself thought it more probable that they were natural beds left aside by some shift in the course of the river. The lime was sold at Sydney for a shilling a bushel,¹² and the commandant, Major Morisset, was also expected to maintain a stock of 1,200 bushels in the lime store. In 1816 Captain Wallis established the Limeburner's Bay settlement north of Stockton, on the Hunter River. When this was abandoned for Port Macquarie in 1823 the manufacture was continued by free settlers, who sold the lime to nearby squatters, and shell boats traded on the river until at least 1838.¹³ At Twofold Bay a large heap of 'mud-oyster' shells which were burnt for lime in the 1840s was reported to have been brought 'from distant shores', but it is easier to believe that they were gathered in the immediate vicinity.¹⁴

At Corinella in Victoria shell lime was burnt in 1826, and shell lime was burnt by John Allee in early Melbourne for a short time until sources of limestone were discovered. From December 1837 until at least October 1838 government gangs were

⁶ Dennis Jeans, 'The Building Industry: Materials and Styles', in Judy Birmingham, Dennis Jeans & Ian Jack, *Industrial Archaeology in Australia: Rural Industry* (Richmond [Victoria] 1983), p 104.

⁷ Hanut Dodd, 'Lime and Victorian Buildings' (MPD, University of Melbourne, 1997), p 54.

⁸ Michael Cannon [ed], *Historical Records of Victoria*, III, (Melbourne 1984), p 271.

⁹ Dodd, 'Lime and Victorian Buildings', p 58.

¹⁰ Jeans, 'The Building Industry', p 105.

¹¹ Warwick Gemmill, *And So We Graft from Six to Six* (North Ryde [New South Wales] 1986), p 5.

¹² W C Wentworth, *Statistical, Historical and Political Description of the Colony of New South Wales* (London 1819), p 56.

¹³ Windross & Ralston, *Historical Records of Newcastle, 1797-1897* (Newcastle 1897), cited in [James Tucker] 'Giacomo de Rosenberg' [ed Colin Roderick], *Ralph Rashleigh, or the Life of an Exile* (Sydney 1952 [1929]), p 242. See also C J Mitchell, *Hunter's River* (Sydney 1973), pp 7-8.

¹⁴ H P Wellings, *Benjamin Boyd in Australia (1842-1849)* (Bega [New South Wales], no date), p 14.

collecting and burning shells in the vicinity of Melbourne, though limestone was also being used from August onwards.¹⁵ Similarly at Moreton Bay [Brisbane] shells were burnt for lime until Captain Logan travelled up the Bremer and found limestone. A specimen of this was sent to Sydney in April, and within a few months a kiln was built at what was then known as Limestone Hills [Ipswich].¹⁶ Shell lime was also used in New Zealand, and in 1840 the best spot for collecting shells was reported near the site of Auckland.¹⁷ On the Clarence River in New South Wales the only lime available was that manufactured from oyster and cockle shells, and it was in use at least until 1866,¹⁸ and at this time shell lime was also being produced at Port Arthur, Tasmania.¹⁹

Coral was an alternative raw material in the more northerly parts of Australia. In 1846 Andrew Petrie is thought to have burnt both shells and coral at Cleveland for use in the building of 'Newstead House', Brisbane,²⁰ and both materials were burnt in the kiln established on St Helena island in 1869.²¹ Even in the 1880s both shells and coral were used at Palmerston [Darwin].²²

b. rock lime

Elsewhere the situation was to be different. At Norfolk Island there was found limestone suitable as a building material in its own right, as well as for burning, and this enabled the construction of durable buildings even in the very first years. By 1793 sacks of lime were being sent to Sydney in the *Kitty*.²³ Limestone was burnt successfully at Collins's Sorrento settlement in Port Phillip Bay, of 1803-4, but not used after the settlement was abandoned. In Van Diemen's Land (Tasmania) Lieutenant-Governor Paterson on his first arrival at Port Dalrymple in 1804 reported the discovery of limestone, though it proved unsuitable for burning, and within a few weeks a better lime was being made from shells.²⁴ Limestone was also found near Hobart.²⁵ By 1816 a limestone quarry had been opened near Hobart, 'the Mortar from which is extremely good for Masons' Work, but not so good as Shell-Lime (which is to be had in the greatest abundance) for the Plaisterer's use'. Limestone had also been burnt at Gunning's estate on the Coal River, and deposits had been discovered in other parts of the island.²⁶

¹⁵ Cannon, *Historical Records of Victoria*, III, pp 270-279.

¹⁶ J G Steel, *Brisbane Town in Convict Days 1824-1842* (St Lucia [Queensland] 1975), pp 54, 73.

¹⁷ John Stacpoole, *William Mason* (Auckland 1971), p 30.

¹⁸ Intercolonial Exhibition of Australasia, *Official Record* (Melbourne 1867), p 61.

¹⁹ Intercolonial Exhibition *Official Record*, p 74.

²⁰ Clem Lack, *Newstead House* (Brisbane, no date), p 5.

²¹ Allom Lovell Marquis-Kyle, 'St. Helena Island Measurement and Assessment of Structures Component Reports' (Brisbane 1989), no M514.

²² *Australasian Builder & Contractor's News*, 8 September 1887, p 358.

²³ David Collins [ed Maria Collins, James Collier], *An Account of the English Colony in New South Wales* (Christchurch 1910 [1798 & 1802; 1804]), p 177.

²⁴ E G Robertson, *Early Buildings of Southern Tasmania* (2 vols, Melbourne 1970), I, p 15.

²⁵ Charles Jeffreys, *Van Diemen's Land* (London 1820), quoted in C R Stone & Pamela Tyson, *Old Hobart Town* (Lilydale [Victoria] 1978), p 58.

²⁶ *Hobart Town Gazette*, I, 3 (15 June 1816), p 2.

Only in the 1820s were deposits of limestone and marble found in inland New South Wales,²⁷ for example at McArthur's property at Cowpastures, where limestone was burnt in 1821, allegedly for 'cement',²⁸ and north of the Mount Horrible Road near Bathurst, from 1822.²⁹ Lime was nevertheless in short supply in most inland parts of the colony, and as late as 1826 James Atkinson suggests that the settler's stone chimney should be built with loam as mortar.³⁰ The same loam, mixed with some coarse grass, will serve as a first coat in plastering, then there should be a second coat containing 'a portion of lime', and the whole should be whitewashed.³¹ The lime from Bathurst had no impact in Sydney because of the difficulty and expense of transporting it over the Blue Mountains, but lime from Picton and Argyle was being sold in Sydney in the 1840s. After the railway was put through Marulan lime became the favoured type for bricklayers,³² and by the 1870s limes burnt from the Marulan and Manning River stones were standard items on the Sydney market.³³ However lime was also brought from Victoria, and by 1880 shell lime had been completely superseded.³⁴

In Van Diemen's Land rock lime was found in various parts, and the distribution of stuccoed buildings, which were common in the north and rare in the south, was determined more by the lack of good freestone in the north than by the distribution of limestone. In the 1830s several kilns were operated by the government near New Norfolk.³⁵ In Western Australia limestone was available at both Albany and Fremantle, but at Albany shells were burnt in preference to stone in 1826-7.³⁶ Lime was used in the construction of the Round House at Fremantle in 1831, and according to Pearson it would have been burnt either in shallow pits or in small masonry kilns.³⁷ At Rottneest Island, as at Albany, though limestone was quarried for building purposes, shells were burnt to get lime for mortar and stucco.³⁸ Near Perth, limestone could be got from Mount Eliza.³⁹ None had been found in the vicinity of York, and in

²⁷ Robert Irving, 'The First Australian Architecture' [MArch, University of New South Wales 1975], p 149, citing Herman, p 134; Freeland, p 68; Bigge Enquiry C.O. 201/122, p 58. Irving claims the same for Van Diemen's Land, but this is contradicted by the *Hobart Town Gazette* report, *supra*.

²⁸ Morton Herman, *The Early Australian Architects and their Work* (Sydney 1954), p 98, quoting Henry Kitchen to Commissioner Bigge, 1821, Bigge Appendix, box 27, 6449.

²⁹ R I Jack in Hughes Trueman Ludlow, *Evans Shire Council Heritage Study* (2 vols, no place, 1987), I, [no page] theme 6.

³⁰ James Atkinson, *An Account of the State of Agriculture and Grazing in New South Wales* [London 1826], p 97.

³¹ Atkinson, *Agriculture and Grazing in New South Wales*, p 97.

³² Gemmell, *And So We Graft*, p 5.

³³ Charles Mayes, *Australian Builders' Price-Book* (3rd ed, Melbourne 1877), p 44.

³⁴ Gemmell, *And So We Graft*, p 5.

³⁵ David Burn, *A Picture of Van Diemen's Land* (Hobart 1973 [1840-41]), p 89.

³⁶ Report by Major Lockyer, *Historical Records of Australia*, 3/6, pp 481, 485, 489, quoted in P J F Coutts, *Corinella: a Forgotten Episode in Victorian History* [Records of the Victorian Archaeological Survey No. 15] (Melbourne 1983), p 146.

³⁷ Michael Pearson, 'Archaeological Interpretation and Ethnographic Analogy: the lime industry in Western Australia', *Archaeology in Oceania*, XXI, 1 (April 1986), p 94.

³⁸ R J Fergusson, *Rottneest Island: History and Architecture* (Nedlands [Western Australia] 1979), p 21.

³⁹ D C Markey, 'Pioneer Perth', in J Gentilli [ed] *Western Landscapes* (Nedlands [Western Australia] 1872), p 56.

the 1860s the government offered a reward of £40 for its discovery.⁴⁰ At Darwin in the 1870s lime was made from the local coral.⁴¹

It was not long after the settlement of Melbourne that John Pascoe Fawkner remembered the rock lime which had been used in 1803-4 at the abortive settlement of Sorrento, where he had been as a child, and from 1839 an extensive trade developed in lime from Point Nepean, some of it for export to Sydney. Other sources of limestone had been found at Geelong and elsewhere which would produce a slightly hydraulic lime, and it was this that at last made external stucco reasonably durable. Thus it was that Melbourne, in contrast to Sydney, developed a stuccoed architecture of a sort now outmoded in Britain itself. 'I am sorry to say that the demon of Roman cement has doubled the Cape, and begun to revel in all the luxuries of the Regent-street school of architecture' wrote a visitor in 1845,⁴² though most of the stucco which conveyed this impression would not in fact have been made with imported Roman cement, but with locally burnt rock lime.

Less attention was paid to mortar, which was often made with inferior lime, if any, and with loam rather than sand. Lime was also used in conjunction with ash and other materials (such as ox blood) prescribed in the various traditional British recipes to create primitive concrete floors, as has been discussed above. Lime was only very gradually replaced by cement, and even in the twentieth century mortar mixes containing both material were common. However the production of lime was concentrated in fewer and larger works, and by the 1890s Waratah Bay lime was regarded as the best in Victoria, and also well received in New South Wales.⁴³

c. lime burning

Lime was at first burnt in bush kilns, in which there was no permanent structure, and the stone and fuel were stacked in alternate layers. At Newcastle, according to W C Wentworth, the process of making lime from oyster shells was simple and quick: 'They are first dug up and sifted, then piled over large heaps of wood, which are set fire to, and speedily convert the superincumbent mass into excellent lime.'⁴⁴ Harrington distinguishes simple heap burning from pit burning, and this in turn from pye or clamp kilns.⁴⁵ There is no clear evidence of these types in Victoria, but Pearson has reported pits at Limekilns, New South Wales.

At all major sites permanent kilns were soon developed. These were typically in the form of an inverted cone, and were usually built into a slope or cliff face to reduce the

⁴⁰ [Janet] Millett, *An Australian Parsonage* (London 1872), p 71.

⁴¹ Harriet Daly, *Digging, Squatting, and Pioneering Life in the Northern Territory of South Australia* (London 1887), p 110.

⁴² Charles Griffith, *The Present State and Prospects of the Port Phillip District of New South Wales* (Dublin 1845), pp 4-5.

⁴³ Waratah Bay lime was exclusively named in the specifications for the Commercial Bank of Australia headquarters in Melbourne, in 1890: G W Blackburn, 'The Commercial Bank of Australia Limited New Premises, &c' [bill of quantities] (Melbourne 1890), passim.

⁴⁴ Wentworth, *Colony of New South Wales*, pp 56-7.

⁴⁵ Jane Harrington, *An Archaeological and Historical Overview of Limeburning in Victoria* (Melbourne 2000), pp 7-8.

amount of construction required. The inverted cone form was used at St Helena Island, Moreton Bay, where a kiln in use by 1869 was built into the side of an escarpment, with stone walls, bell-shaped brick chimney, and a brick draw hole at beach level. The raw materials were coral and shells collected on the island, and the lime was not only used for the construction of buildings but also, it seems probable, for the production of sugar at a somewhat later date.⁴⁶ Other such kilns were at Norfolk Island; Garden Island, Sydney; and Portland, Victoria, while at Limeburner's point, Victoria, the kilns are of even deeper, shaft-like proportions. However this form seems to have been unknown in Western Australia, and Michael Pearson reports at Albany circular, square and rectangular (deeper than wide) kilns of this character - that is, built into a bank. He is unable to present their vertical sections, but he describes the circular one as being a cylinder 2.5 m tall and 2 m in diameter. In other words it is not conical like those in Victoria, and it is quite squat in proportion. These kilns at Albany were used intermittently until World War II. Pearson reports other circular kilns at Ludlow, south of Bunbury, which are not in a bank, and must have an artificial construction of some sort behind them for loading purposes.⁴⁷

Common lime burning, as it continued through the later nineteenth and early twentieth centuries, tended to rely upon more capacious rectangular kilns, known as 'D-kilns' in New South Wales. Michael Pearson describes similar kilns in Western Australia, including those at Coogee, near Fremantle (dating from the late nineteenth century), at Bullsbrook, north-east of Perth (undated), at Yallingup, south-west of Busselton (1922), and a double kiln at Wanneroo, north of Perth (1955 and 1957).⁴⁸ At David Mitchell's Cave Hill Lime-Works at Lilydale, near Melbourne, the kilns were of a different form, ovoid at the base but with perpendicular sides. The limestone was stacked in alternate layers with fuel, and the burnt lime was drawn out at the basis in a standard way. In the 1880s there were five such kilns, and three hundred tonnes of lime were produced per week.⁴⁹ Flare kilns, in which the fuel and the limestone are kept separate, give a less adulterated product but tend to be less efficient, producing a high proportion of underburnt and overburnt material. According to Harrington the only Victorian examples were Dibley's at Coimadaí, as first operated, and the Fossil Beach Cement Works (discussed below).⁵⁰

d. hydraulic lime and cement

⁴⁶ Allom Lovell Marquis-Kyle, *St Helena Island: Measurement and Assessment of Structures: Component Reports* (Brisbane 1989), no M514.

⁴⁷ Pearson, 'Archaeological Interpretation and Ethnographic Analogy', pp 99-101. Pearson cites for the respective sites: P Harmon-Price, 'St Helena Island Management Plan: Part 3, Buildings and Structures Outside the Prison Stockade (Queensland National Parks Service, Brisbane, 1980); G Wilson & M Davies, 'Norfolk Island : Archaeological Survey Kingston-Arthur's Vale Region' (Department of Housing and Construction, Canberra, 1981); J S Kerr, 'Goat Island: An Analysis of Documentary Evidence &c' (Maritime Services Board, Sydney 1985); C Eslick, 'Historical Archaeological Sites in the Portland Area' (ms report, Victoria Archaeological Survey, May 1983). See also Michael Pearson, 'The Lime Industry in Australia - an Overview', *Australian Journal of Historical Archaeology*, VIII (1990), pp 28-35.

⁴⁸ Pearson, 'Archaeological Interpretation and Ethnographic Analogy', pp 95-99.

⁴⁹ *Australasian Builder & Contractor's News*, 24 November 1888, p 476.

⁵⁰ Harrington, *Limeburning in Victoria*, p 9.

In the late eighteenth century a number of so-called cements, actually limes with pozzolanic additives, were developed in Europe. They probably had some small impact in the first years of the Sydney settlement, but they were soon superseded by Parker's 'Roman' cement, and then by Portland cement, so they need be mentioned only briefly here. In both Britain and Australia there were some rock limes which by reason of their composition, particularly if the stone contained a proportion of clay, produced a material with some hydraulic properties. A true hydraulic lime cannot be slaked, will set even under water, and when used as stucco on the outside of a building will be able resist the weather. In Britain the best known type was the blue lias lime found in the west of England.⁵¹

The engineer John Smeaton used blue lias lime in the 1750s in the construction of the Eddystone Light, but added *terra puzzulano*, which was available, more or less fortuitously, from a Plymouth merchant.⁵² The addition of pozzolano and other materials to lime is a traditional practice, quite distinct from the manufacture of artificial cement. Such mixtures were developed to a high degree by Brindley Higgins, who published his results in 1780,⁵³ and may conceivably have been influential in Australia. Higgins patented one recipe⁵⁴ and licensed it to be used by the builder Samuel Wyatt, and the architect James Wyatt,⁵⁵ only shortly before the latter was to form his partnership with James Parker in the development of natural cement.

In 1774 Antoine-Joseph Lorient published his cement in the *Mémoire sur une Découverte dans l'Art de Bâtir*.⁵⁶ This was followed immediately by an English edition which sold out, a success which Eileen Harris attributes to the facts that the invention was fully explained in the book but not protected by patent, and that the publication coincided with the *London Building Act, 1774*.⁵⁷ Lorient's 'cement' was in fact no more than a mixture of sand, brick dust and either quicklime or old slaked lime (according to his two recipes),⁵⁸ and Higgins dismissed it entirely, apart from acknowledging that lime was at least a better ingredient than whiting.⁵⁹ Higgins was promoting his own cement, which was at least the result of a process of experimental development, but it, in its turn, could not compete with the natural or 'Roman' cement discovered a few years later.

⁵¹ John Wood, *A Series of Plans for Cottages or Habitations of the Labourer* (London 1806 [?1781]), pp 7-.

⁵² Samuel Smiles, *Lives of the Engineers* (3 vols, London 1862), II, p 37.

⁵³ Bryan Higgins, *Experiments and Observations [on] Calcareous Cements* (London 1780), passim, especially pp 182 ff.

⁵⁴ British patent no 1207, to Bryan Higgins, 23 April 1779, reproduced in A C Davis, *A Hundred Years of Portland Cement* (London 1924), pp 227-231.

⁵⁵ Bryan Higgins, *Experiments and Observations [of] Calcareous Cements*, (London 1780), passim, especially pp 182 ff.

⁵⁶ A-J Lorient, *Mémoire sur une Découverte dans l'Art de Bâtir, - la Méthode de Composer un Ciment ou Mortier Propre à une Infinité d'Ouvrage, tant pour la Construction que pour la Décoration* (Paris 1774) ref Wyatt Papworth [ed], *The Dictionary of Architecture* (6 vols, London 1853-1892), sv '(Antoine Joseph) Lorient'.

⁵⁷ Eileen Harris, *British Architectural Books and Writers 1556-1785* (Cambridge 1990), p 301.

⁵⁸ Papworth, *Dictionary of Architecture*, sv '(Antoine Joseph) Lorient'. Harris interprets it as a single recipe using both quick and slaked lime.

⁵⁹ Brindley Higgins, *Experiments and Observations ... of ... Calcareous Cements* (London 1780), pp 228-9.

Roman cement was the invention, or more precisely the discovery, of James Parker of Northfleet in Kent, who found that septaria nodules found on the Island of Sheppey, or by extension other naturally occurring combinations of clay and limestone, would produce a hydraulic cement. Parker's patent of 1796 provided essentially that this material should be burnt to a high temperature and ground to produce a stronger cement than any hitherto available,⁶⁰ and one which could resist weathering and even had some capacity to set under water. It was manufactured and marketed by Parker in partnership with the architect James Wyatt, and was the basis of the durable stucco which characterises the English Regency style. In France comparable nodules were found at Boulogne, and a clay beneath this stratum was the only identified natural cement in the form of a soft deposit.⁶¹ The principal brands, according to Hurst, were Harwich, or Frost's; Francis and Grellier's, made at Millwall; Atkinson's or Mulgrove's [*sic*, for Mulgrave], from Whitby in Yorkshire; Calderwood, from Glasgow; and Medina, from Hampshire and the Isle of Wight.⁶² But of these Frost's at least is better described as an artificial cement, and is discussed in that context below.

In 1821 the Sydney architect Henry Kitchen told Commissioner Bigge that limestone had been burnt to produce cement at MacArthur's property at Camden, but this can at best have been only a mildly hydraulic lime, or much more would have been heard of it.⁶³ In practice all such materials were imported for some time to come. Parker's cement was available in Sydney at least by 1826,⁶⁴ and was being advertised in 1835 by G S Tucker.⁶⁵ Other more or less adequate hydraulic limes were brought from Port Phillip and elsewhere.⁶⁶ In Adelaide, after the failure of the Torrens Weir, T B Strangways was insistent that North Adelaide lime should on no account be used in public works exposed to water, but only the best hydraulic lime.⁶⁷ In Adelaide that would have meant an imported product, but in Victoria a number of roche or rock limes with hydraulic properties were discovered from the 1850s onwards.

A specification of 1890 calls for 'approved Geelong Waratah [Gippsland] or Lilydale roche lime',⁶⁸ while another specification in that year names these three together with

⁶⁰ British patent no 2120 to James Parker, 27 July 1796, reproduced in A C Davis, *A Hundred Years of Portland Cement* (London 1924), pp 233-5. See also *Repertory of Arts*, second series, XVIII, 108 (May 1811), pp 330-332.

⁶¹ Q A Gillmore, *A Practical Treatise on Limes Hydraulic Cements, and Mortars* (8th ed, New York 1886), p 62.

⁶² Lawrence Hurst, 'The Properties and Uses of Roman Cement', *Construction History*, XVIII (2002), p 27.

⁶³ Henry Kitchen to Commissioner J T Bigge, 13 August 1823, J.T. Bigge Report - Appendix, Bonwick Transcripts, Mitchell Library, box 27, p 6449, cited in James Broadbent, *The Australian Colonial House* (Sydney 1997), p 95.

⁶⁴ *Australian*, 5 April 1826, quoted in Barrie Dyster, *Servant and Master* (Kensington [NSW] 1989), p 105

⁶⁵ *Sydney Herald*, 23 November 1835, reproduced in Ian Evans, *The Australian Home* (Sydney 1983), p 59.

⁶⁶ *Geelong Advertiser*, 28 July 1856.

⁶⁷ *South Australian Register*, 6 October 1858, quoted in E & R Jensen, *Colonial Architecture in South Australia* (Adelaide 1980), p181.

⁶⁸ Hyndman & Bates, 'Specification, &c, Villa Residence Tank +c / Camberwell / Arthur J Fuller Esq / Normanby Chambers Chancery Lane' (Melbourne 1990), p 2.

Coimadai lime.⁶⁹ Coimadai or Pyrete Creek, near Bacchus Marsh, was a source of common lime from the 1850s onwards. By 1886 three lime claims there were in the hands of the Alkemade Hydraulic Lime and Cement Company, a partnership of Petrus Alkemade, builder, and Matthew Egan. Nearby George Dibley also established a Hydraulic Lime & Cement Co. Lime from these sources was in high demand during the building boom of the 1880s, and J C Newbery, chemist at the Victorian Museum, claimed that it was equal to the best imported English hydraulic lime. Dibley's works ceased production in 1892, doubtless as a result of the depression, but Alkemade's continued well into the twentieth century.⁷⁰

As local production of lime was improved in the latter half of the century, the importation of hydraulic lime from Britain and elsewhere (which had been substantial) was reduced considerably. What did not reduce was the importation of cement. Roman cement was probably imported to Australia fairly extensively and used for special purposes. Major Mitchell's memoranda of about 1828 note the desirability of lining a cesspool with Roman cement,⁷¹ but these are probably notes transcribed from English sources, and it does not follow that anything of the sort was being done in Australia. In 1856 barrels of Roman cement were listed amongst the contents of 'Barwon Grange', Geelong. Portland Cement, in which similar proportions of limestone and clay are deliberately achieved by mixing the materials, and which is burnt at a higher temperature and ground more carefully, had been developed in about 1813-24, but only began to be widely accepted in Britain in the 1840s. Both these materials were imported by the Australian colonies, and of course attempts were made to emulate them locally. T H James reported amongst the abandoned detritus at Port Adelaide in 1836 'blocks of Roman cement', now as hard as stone, wanting nothing but the staves and hoops'.⁷²

The first attempts in Australia at producing a hydraulic cement seem to have been those of Charles Mayes in 1853. It does not appear that any system of patents was operating in Victoria at the time (the first patents were issued in the following year, the second being to Mayes himself for his improved pisé, discussed above). However, Mayes claimed to have invented 'an incombustible building material', and on the strength of this sought from Lieutenant-Governor La Trobe a licence to search for and remove 'certain rocks or cement stones for the manufacture of calcareous, hydraulic and other cements' required to make his material, as well as to construct kilns and do other things ancillary to the enterprise. As there was no patent specification we do not know what he had invented. Nor did he gain his licence. The file is annotated by 'JF' [J F L Foster, Colonial Secretary], 'I do not feel at liberty to grant all his applications give the sanguine gentleman a proper answer'.⁷³

⁶⁹ Reed, Henderson & Smart, 'Specification of Work to be done ... New Premises for the Metropolitan Gas Coy.' (Melbourne 1990), p 4.

⁷⁰ Harrington, *Limeburning in Victoria*, p 9, pp 38-9, ref C Johnston, 'Conservation Analysis: Coimadai Lime Kilns' (report to the Rural Water Commission 1986); Melbourne's Living Museum of the West, 'An Oral History of the Coimadai Kilns' (report to the Rural Water Commission 1986).

⁷¹ Sir Thomas L Mitchell Memoranda Book, 1827-1829, Mitchell Library, manuscript ML C38, reel CY 1992.

⁷² T H James, *Six Months in South Australia* (London 1838), p 28.

⁷³ Colonial Secretary's correspondence C 53/9930. See also Mayes's advertisement in the *Argus*, 3 October 1853, p [?3].

The only significant local manufacturer of Roman cement was the Patent Septaria Cement Company at Mornington, Victoria, which constructed its kilns in 1862 and struggled on only until 1865. It was to be more than twenty years before local makers were able to produce Portland cement successfully. The lack of any local source of hydraulic lime or cement meant that the use of stucco was limited in Sydney, though Cunningham speaks of 'brick plastered and whitewashed' as being fairly normal.⁷⁴ Even this does not imply the use of a high grade cement, or even a hydraulic lime, for elsewhere Cunningham proposes an external plaster for slab houses consisting of 'alluvial soil, mixed with a portion of cow-dung to prevent it from cracking, and with chopped straw to enable it to adhere.'⁷⁵ It was essential, according to James Thompson, that brick or stone walls on the south or weather side should be stuccoed 'for, if this is not done, the rain penetrates the bricks or stone, and makes the walls always wet.'⁷⁶ For such purposes 'Roman' cement was imported. Much later William Shearing, of G & W Shearing, South Australian brick and pottery makers, discovered a cement stone within reach of Adelaide, and in 1889 the cement was reported to be available in any quantity.⁷⁷

In Victoria there were abortive experiments with magnesian limestone cements, which probably reflect earlier developments in India. A British colonist in India, Dr Macleod, had discovered the hydraulic properties of magnesian limestone and brought them to the attention of the Madras government. Tests were conducted by A T Cotton of the Madras Engineers, who found magnesian cement to be equal to Parker's.⁷⁸ Its cost was about the same, but within fifteen years it dropped to a tenth due to the discovery of major magnesium deposits at Salem and Trichinopoly.⁷⁹ The new material came into wide use in India, where it was also tested by J T Smith. Next, during the 1830s, Pasley tested magnesian limestones from the north of England, but was not optimistic about their usefulness.⁸⁰ In France Chatoney and Rivot asserted that magnesian limestone produced a superior cement for hydraulic works, but a commission report took the reverse view, and actually recommended that magnesian cements be barred from use. In the United States Q A Gillmore challenged the stance of the French commission and pointed out that the most reliable local limes, under the various Rosendale brands, were from magnesian stone.⁸¹

⁷⁴ Peter Cunningham, *Two Years in New South Wales* (2nd ed, 2 vols, London 1827), I, p 43.

⁷⁵ Cunningham, *Two Years in New South Wales*, II, p 162.

⁷⁶ J[ames] Thompson, letter of 10 August 1833, in *Architectural Magazine*, I (December 1834), p 377.

⁷⁷ *Australasian Builder & Contractor's News*, 16 March 1889, p 249.

⁷⁸ C W Pasley, *Observations on Limes, Calcareous Cements, &c* (London 1838), appendix pp 114-5. Pasley does not name Cotton, but see John Weiler, 'Colonial Connections: Royal Engineers and Building Technology Transfer in the Nineteenth Century', *Construction History*, XII (1996), pp 4-5, ref A T Cotton, 'Magnesia Cement', *Professional Papers of the Madras Engineers*, I (1845), p 28.

⁷⁹ Weiler, 'Colonial Connections', p 4, ref J M Brown, 'Contributions of the British to Irrigation Engineering in Upper India in the Nineteenth Century', *Transactions of the Newcomen Society*, LV (1983-4), pp 85-112.

⁸⁰ Pasley, *Limes, Calcareous Cements, &c*, p 28.

⁸¹ Gillmore, *Hydraulic Cements and Mortars*, pp 304-5. See also pp 48, 49, 51 & 53 for the Rosendale companies.

Specimens of newly discovered limestones were tested by J G Knight in a small kiln set up for the purpose in 1859, and produced a hydraulic cement. Amongst these, it seems, were the 'shelly or magnesian' limestones used in combination with ironstone to produce a cement according to a patent taken out by T P Edwards in 1862. Edwards seems to have referred to two different stones, a shelly limestone from the coast near Geelong and elsewhere, and a magnesian limestone or dolomite discovered in the excavation of the Reilly Street drain at Collingwood. Although the latter was reported in the *Australian Builder* as a likely source of 'good artificial cement', it seems to have contained such a mixture of ingredients as to be almost a natural cement stone, and was clearly inspired by the success of magnesian cement in India. Edwards was followed by W H Hughan, who made two patent applications, of which one was granted, for a cement using clay and quartz tailings. The other, for 'Hughan's Portland Cement', was refused in 1861, probably because it used magnesian clay and was similar to Edwards's patent.⁸² It would seem that it should not be regarded as a Portland cement, but it is not clear whether Hughan was a local resident or an overseas applicant.⁸³

Identifying examples of Roman cement is a difficult matter, but a promising example is the mass concrete house 'Craiglee' at Sunbury, Victoria, dating from 1865. An analysis by L I Ebbels, of Sharp & Howells, has shown that the components are more consistent with Roman cement than anything else, on the grounds that the proportions of alumina and ferric oxide are much higher than in Portland cement.⁸⁴

	Portland cement	Craiglee sample
calcium as oxide CaO	64	64
soluble silica SiO ₂	22	23
aluminium oxide & ferric oxide Al ₂ O ₃ & Fe ₂ O ₃	7 - 12	23

The balance of probability would be that the house was built using the cement of the Schnapper Point company, which operated up until the year of its construction.

⁸² Lewis, 'Tradition and Innovation', II, p 310-13.

⁸³ Hughan was later to obtain a British patent for the use of Portland, Roman and other cements in deodorizing works: Great Britain, patent no 2893 to W H Hughan, 19 September 1868. Also related patents, no 67, 8 January 1879; no 3060, 30 November 1871; no 2700, 20 August 1873; no 1959, 5 June 1874.

⁸⁴ The figures from analysis of oven-dried samples of the concrete were CaO = 14.7%; SiO₂ = 5.3%; Al₂O₃ = 2.5%; Fe₂O₃ = 2.8 %. These were converted to a base of CaO = 64 for the purpose of comparison. L I Ebbels to E Sharp, 12 June 1978.

e. mortar and grout

There is little distinctively local about the use of mortar in Australia, but there are some regional variations both in the materials used and in their application. Animal hair also might be mixed in the mortar,⁸⁵ or human hair if necessary: in 1832 it was reported that four hundred convicts were being shorn at Norfolk Island to provide hair for the purpose.⁸⁶ In a specification for houses near Melbourne in 1854 the foundation walls were of coursed bluestone rubble, 'courses to be grouted with good hot lime grout'. The mortar in the walls was to be one part of Port Phillip lime to three of loam and sand, in equal proportions, 'well mixed with pure water and to be made up in large banks until approved by the Architects.' The mortar used by the plasterer was to be

one part of good fresh Port Phillip lime and two of sand and loam in equal proportions with the addition of sufficient quantity of long pile hair. The fine stuff to be well soaked and may have a small quantity of washed sharp drift sand added.

In the same houses of 1854 the underside of the roofing slates was to be parged (that is, sealed with a rough render) with Roman cement.⁸⁷ In a similar way the slate roof of W M Bell's warehouse in Melbourne in 1856 was 'rendered with hair mortar', presumably on the underside, but a specification of 1891 required only the top course of slates and the hips to be bedded in a hair mortar.⁸⁸ A specification of 1878 required the builder to 'properly parget the flues with lime mortar mixed with cow dung, and afterwards core the same'.⁸⁹

In 1867 J H Stanton, clerk of works for the construction of a country homestead, conducted what seems to have been an experiment to develop a means of monitoring the amount of lime used on a job.

... Made up a Bed of Mortar as Follows,

put one Bag of Fresh unslacked Lime into the Box used for running lime into

Lime mortar continued in use in Australia long after Portland cement became common, not only because it was cheaper but because its properties were in some respects superior - for though it was no not so strong it was more flexible and indeed self-healing. In 1891 the architect W S Law required his mortar to be of Lillydale lime (that produced near Melbourne by David Mitchell) and clean sharp grit sand in

⁸⁵ Gilbert White recorded in his diary 'Sheared my mongrel dog Rover, and made use of his white hair in plaster for the ceiling': quoted in Joanna Capon, *Plaster Work* (Milsons Point [NSW] 1992), p 11.

⁸⁶ *Sydney Herald*, 27 February 1832, p 3, quoted in Ian Evans, *The Australian Home* (Sydney 1983), p 35.

⁸⁷ Russell, Watts & Pritchard, 'Specifications for ... Dwelling houses ... at Elwood .. for Joseph Docker', 13 December 1854, Docker papers, State Library of Victoria, pp 2, 6-7, 18.

⁸⁸ W S Law, 'Specifications of Residence Drummond St. Carlton for Mrs. L. Abrahams' (Melbourne 1891), p 25.

⁸⁹ Reed & Barnes, 'Specification of Work to be done and Materials to be used in the Erection of Banking Premises at "Kooringa S.A." for the Bank of Australasia (Melbourne 1878), p 11.

the proportion of three bags of lime to one 'load' of sand, well mixed, and allowed to stand for a week before being used.⁹⁰

f. stucco

The lack of any local source of hydraulic lime or cement meant that the use of stucco was limited in early Sydney, though less restricted in most other major settlements. Traditional stucco was strictly speaking made of gypsum plaster, but this was so rarely used for external work in either Britain or Australia that we must understand the term to normally refer to a composition, 'compo' as it was known, of sand and cement. There were in theory ways of producing a reasonably durable stucco from a good common lime, though there's little evidence of this in Australia. In Britain in 1776 Dr Brindley Higgins had given a public lecture course in chemistry, in which he described his various recipes for making a durable mortar by mixing in bone ash and other pozzolanic materials. In 1779 he took out a patent for his preferred method, and he licensed James and Samuel Wyatt (architect and builder respectively) to use the material.⁹¹ Whether any use was made in Australia of Higgins's mixture it is impossible to say, but it must have been quickly overtaken by Parker and Wyatt's 'Roman Cement'. The advantage of Parker's or Mulgrave's Roman cement, and indeed of gypsum plaster, was that it set rapidly. Frost's 'cement' (actually a hydraulic lime, though Frost did later produce a cement), was slower, especially as it was sometimes mixed with common lime. So was Bailey's composition, a stone lime slaked immediately after burning and mixed with three parts of clean sharp sand.⁹² By the mid-nineteenth century the usual options for an external compo or stucco in Britain were Roman, Portland, Bailey's, Johns's, Brown's or Robinson's cement, and London builders often used the same materials for internal plastering, running cornices and casting ornaments.⁹³

Externally the aim was always to imitate the appearance of stone, and a typical English specification for an exterior stucco surface the early nineteenth century was 'to lath, lay, set, and colour stone colour ...'⁹⁴ It was essential, according to James Thompson, that brick or stone walls on the south or weather side should be stuccoed 'for, if this is not done, the rain penetrates the bricks or stone, and makes the walls always wet.'⁹⁵ For such purposes 'Roman' cement was imported. The addition of materials other than pigments is not recorded in Australia, though it has a long history elsewhere, especially in Italy, where the Achaean Greek temples, being of inferior stone, were coated in a plaster containing crushed marble. In the Renaissance much the same was done, using a stucco known as *marmorino*, which achieved a marble effect by the addition of powdered seashells and travertine marble dust, and was

⁹⁰ Law, 'Specifications ... for Mrs. L. Abrahams', p 3.

⁹¹ Higgins, *Calcareous Cements*. p.

⁹² J C Loudon, *Encyclopædia of Cottage, Farm and Villa Architecture* (London 1846 [1833]), § 527, p 259.

⁹³ *Builder*, XII, 585 (21 April 1854), p 207.

⁹⁴ Loudon, *Cottage, Farm, and Villa Architecture*, § 830, p 421.

⁹⁵ J[ames] Thompson, letter of 10 August 1833, in *Architectural Magazine*, I (December 1834), p 377.

pressed with a hot iron after being applied.⁹⁶ It was also common in Italy, and likewise in British Georgian architecture, to rule the surface in imitation of ashlar masonry.⁹⁷

The second government house at Parramatta, built by Hunter in 1799, had a stucco finish grooved to imitate stone, as will be mentioned below, and it would be of some interest to know what lime was used for it, or whether some of the new Roman cement was imported for the purpose. The locally burnt lime was of course not sufficiently waterproof to make a really durable external stucco, and as soon as good bricks could be made they were adopted as the main material for important public buildings. This is characteristic of the work of our first important architect, Francis Greenway. It is by no means clear how a durable stucco was achieved in most early buildings, but it is notable that for two good quality terrace houses in Melbourne a specification of 1854 called for a stucco of Sullivan's artificial stone, a material to be discussed below.⁹⁸

A resemblance to ashlar masonry was commonly attempted by ruling the stucco in an ashlar pattern divided by shallow grooves, pencil or crayon lines, or both. Such ruling was common, for example, in John Lee Archer's work in Van Diemen's Land. It might also be tinted or washed over to give it a more credible colour. One of the earliest examples is at Old Government House, Parramatta, where the front pile was built in 1799-1800, and the depth doubled in 1812-16. In recent years part of the original rear wall surface has been exposed to reveal the finish as it was in 1812, if not 1800. It is a light whitish colour, mottled rather unconvincingly with an ochreous pigment, and ruled as ashlar using a thick pencil or crayon. Specifications rarely give any details of this ruling process, but say something like 'well hand floated trowelled rubbed up and lined off as may be directed by the Architects.'⁹⁹ Various washes were marketed in England for use on stucco, to enhance its resemblance to the more fashionable building stones, and the best known of these, Johns & Co's Patent Permanent Stucco Wash, was marketed in Melbourne by Dickson, Williams & Co.¹⁰⁰ More commonly such washes were made up on the job, some of them actually containing cement, with or without size, and others based upon materials such as plaster of Paris or lime.¹⁰¹

Portland cement was to acquire its name in England because of its resemblance to Portland stone when used as a stucco. This was undoubtedly its major use in the Australian colonies as well, especially on important public buildings, such as the St Kilda Town Hall, Melbourne, in 1859.¹⁰² Most subsequent buildings of any architectural elaboration depended upon Portland cement, either because they included castings and mouldings which required it, or because they were fully coated

⁹⁶ This was used at Palladio's villa 'La Malcontenta': Witold Rybczynski, *The Perfect House* (New York 2002), pp 93-4.

⁹⁷ Rybczynski, *The Perfect House*, pp 4, 60, 94.

⁹⁸ Russell, Watts & Pritchard, 'Specifications for ... Dwelling houses ... at Elwood .. for Joseph Docker', 13 December 1854, Docker papers, State Library of Victoria, p 19.

⁹⁹ Russell, Watts & Pritchard, 'Specifications for Dwelling houses at Elwood', p 19.

¹⁰⁰ Charles Mayes, *Victorian Contractors' and Builders' Price-Book* (Melbourne 1859), p x.

¹⁰¹ P N Hasluck, *Cassell's House Decoration* (London 1910), pp 159-60.

¹⁰² *Australian Builder*, 24 December 1859, p 409, quoting the *St Kilda Chronicle*.

in it, as was the case with 'Mandeville Hall', Melbourne, in 1877.¹⁰³ Indeed by 1877 Mayes could say that, for external work, stucco or lime plaster had been entirely superseded by Portland cement 'compo' [composition mortar] in Melbourne and Sydney. Nevertheless, specimens of stucco twenty years old were to be found in Sydney, still in good condition, and in country districts where limestone was available, lime might still be the best material to use. If it were properly coated, and treated with chunam, it would be just as durable as cement compo.¹⁰⁴ The word 'chunam' had a meaning other than its original Indian one - a fine plaster of shell lime, jaghery water [sugar water], egg white and ghee [clarified butter] in various proportions.¹⁰⁵ Mayes meant a mixture of one bushel [0.36 m³] of lime to two gallons [9 l] of best 'thin black oil'.¹⁰⁶

Hornabrook's shops in Adelaide were completed in 1887 with a brick front and cement bands, dressings, cornices and pilasters, all coloured in imitation of stone.¹⁰⁷ Whether the colour was integral or in the form of a wash or paint is unclear, for Portland cement was not necessarily treated with a stucco wash. Contrasting colours in the cement might be used to enhance the appearance of the building. John Sulman referred in 1887 to shops in Bond Street, Sydney, where 'the mouldings and their ornaments are run in a white cement in contrast with the plain grey of the body of the walling, and the effect is by no means unsatisfactory'.¹⁰⁸ A surviving example of such a treatment is 'Noorilim' homestead near Nagambie, Victoria.

More commonly cement render was left in its natural colour, which itself depended very much upon the brand of cement used and the choice of the sand. In one instance, 'Benvenuta' in Melbourne, the work was formed using Knight, Bevan & Sturge's, the leading British cement, but finished in the German 'Stern' or star brand, with different sands in the two mixes, and with the finished surface ruled as blockwork:

The whole of the outside cement work to be Worked in Knight Bevan's and finished in Star brand, composed of three parts of washed Sandridge sand with one of cement for the first coat and two parts of washed Caulfield sand with one of cement for the fining. To cement in two coats as above described, the whole of the external brickwork (excepting back walls of the main building above conservatory roof and to outbuildings) also inside walls of Conservatory and face of retaining wall to same also insides and tops of parapets and shafts of chimneys. The whole finished to an even thickness of $\frac{3}{4}$ " and to a uniform colour, all to be block lined (with the exception of the insides of parapets) including cross joints to all mouldings and arches. The whole of the face mouldings to be run clean and sharp and all work to be of an even colour and well watered at the various stages of progress.¹⁰⁹

¹⁰³ *Town and Country Journal*, 3 March 1877, p 348.

¹⁰⁴ Mayes, *Australian Builders' Price-Book* (1877), p 85

¹⁰⁵ Smith's note in L J Vicat [translated J T Smith], *A Practical and Scientific Treatise on Calcareous Mortars and Cements* (London 1837), p 136.

¹⁰⁶ Mayes, *Australian Builders' Price-Book* (1877), p 97.

¹⁰⁷ *Australasian Builder & Contractor's News*, 3 September 1887, p 267.

¹⁰⁸ *Australasian Builder & Contractor's News*, 11 June 1887, p 72.

¹⁰⁹ Law, 'Specifications ... for Mrs. L. Abrahams', p 44.