

7.08 *Forms & Systems*

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The period following the Great War was that in which reinforced concrete became a familiar and accepted material, rather than the province of a few specialist firms and important buildings. Part of this was due to promotion. The magazine *Australasian Concrete* was published in Sydney between 1919 and 1922, and was followed from 1922 by *Highways*, the magazine which is still published today as *Constructional Review*. We are not concerned here with the roads and bridges, high rise buildings, and more specifically engineering developments in concrete. But we are here concerned with the great expansion in the use of concrete for ordinary housing and general purposes.

a. formwork systems

In Britain Joseph Tall invented a construction system to build high thin walls of Portland cement concrete, something difficult to do before his time. His invention was a framework containing moveable panels, by means of which all the walls could be carried on simultaneously, so that the walls of any ordinary house were completed within a week.¹ The concrete was placed in about 750 mm courses.² It appears that he was willing to use a variety of materials, including burnt clay, gravel, stone, crushed slag, clinker, oyster shells, and broken glass and crockery. For houses at Gravesend he used seven parts of burrs [clinkers] from a brickfield, seven of gravel, and one of Portland cement.³ By 1869 Tall had built numbers of houses in England on this system, and was reportedly building nine-roomed houses in the Boulevard Daumesnil for the Emperor of France.⁴ When Tall's system first appeared in Australia is not known, but a telling piece of evidence is a broadsheet found loose

¹ E L Blackburne [ed], *Suburban and Rural Architecture* (London, no date [c 1869]), pp 95-6. A pair of two storey semidetached houses built by Tall in 1866 at Bexley Heath in Kent is illustrated in C J Stanley, *Highlights in the History of Concrete* (Slough [Buckinghamshire] 1980 [1979]), p 18.

² Charles Mayes, *The Australian Builders' Price-Book* (4th ed, Melbourne 1883), p 22.

³ C J Richardson, *The Englishman's House from a Cottage to a Mansion* (London 1870), pp 90-91.

⁴ Blackburne, *Suburban and Rural Architecture*, pp 95-6.

within a bound folio of drawings of the Victorian architect Nathaniel Billing, mostly dating from the 1850s and 1860s.⁵ By 1883 Tall's system is explicitly referred to in Australia.⁶

'Down Hall' in Essex is reported to have been completed in 1873 by the contractor Francis Drake, using a patent formwork system developed from Tall's.⁷ However this can hardly have been Drake's first work, as his system had already appeared in Australia. By 1870 G A and H A Bartlett of Adelaide were advertising as agents for Drake's Patent Concrete Building Company of London,⁸ which produced stone breakers and concrete mixing and building equipment.

The first fully standardised formwork system developed in Australia seems to have been 'Monolyte', developed by S B Marchant of Adelaide. Marchant built houses in Adelaide in 1913 and in Victoria in 1915, and they were said to be 'flawless' a decade later.⁹ By 1925 the system had been developed make it almost foolproof. The formwork panels of a house were set up in twenty-eight hours, and the pour was carried out by a mixer and placer.¹⁰ The formwork was of timber and the walls were of solid concrete, four inches [100 mm] thick externally and three inches [75 mm] internally, reinforced with 5/16 inch [8 mm] bars vertically and horizontally. Partly due to 'secret processes' the walls were reported to be impervious to moisture, and a cavity was unnecessary.¹¹ In 1926 Marchant patented an improved version of the Monolyte system, using 'detachable metal moulds secured to vertical studs and horizontal beams'.¹²

In 1924 the State Savings Bank architect G B Leith built a War Service Home in the Melbourne suburb of Brighton on the system,¹³ and in 1925 twenty-eight houses were built at Sunshine, where in one case the pour took twenty-eight working hours.¹⁴ They were built to house workers at H V McKay's Sunshine Harvester works, and jointly financed by the State Savings Bank.¹⁵ There is reason to believe that five houses built at Sunbury in the early 1920s, four of which survive, may have been of

⁵ Melbourne University Architectural Collection, SLV.

⁶ Mayes, *Australian Builders' Price-Book* (1883), p 22.

⁷ Stanley, *Highlights in the History of Concrete*, p 18.

⁸ *Australasian*, 12 November 1870, p 627.

⁹ G C Ussher, 'The Major Building Factor of the Future: Importance of Reinforced Concrete', *Building and Construction*, 14 July 1925, quoted by Paul Roser, 'Concrete House in Victoria 1900-1940' (GDPG, University of Melbourne, 2000), p 9. Eighteen houses built on this system in 1914-15 were similarly reported, to 'have stood up to every possible test of time': *Australian Home Builder*, 15 January 1925, p 62. There is no apparent connection with the Mono Concrete Co Ltd of England, for which see Oscar Faber & H L Childe [eds], *The Concrete Yearbook 1949* (London 1949), p 921.

¹⁰ *Australian Home Builder*, February 1924, p 50, quoted by Bryce Raworth, *Melbourne's Interwar Detached Housing Estates* (1997), p 53, and in turn by Roser, 'Concrete House in Victoria', p 9.

¹¹ Ussher, 'The Major Building Factor'.

¹² Patent no 22492, quoted in *Building and Construction*, 20 July 1926, and in turn by Roser, 'Concrete House', p 10.

¹³ *Australian Home Builder*, 15 January 1925, p 62.

¹⁴ *Australian Home Builder*, 15 January 1925, p 62; 15 April 1925, pp 60-61; 12 December 1925, pp 68-9. *The Herald*, 26 January 1926, cited by Roser, 'Concrete House in Victoria', p 9, gives the number as twenty-five, and says they were on Leith Avenue and Hampshire Road.

¹⁵ *Suburban Building Record*, 6 October 1925, cited by Roser, 'Concrete House in Victoria', p 9.

the same construction.¹⁶ A building in North Fitzroy of 1926 has been identified by Paul Roser as a possible example of Marchant's improved system, using metal moulds.¹⁷ In the same year the *Australian Home Beautiful* illustrated a concrete house said to have become popular with clients of the State Savings Bank, which sounds as though it may have been Monolyte, and indeed is repeatedly referred to as 'monolythic'. But it had a wall cavity, which is not in accord with Marchant's original system. It was poured in five lifts.¹⁸

Many observers were sceptical of the system, but the Victorian promoter, W R Reusch, persevered and was claimed to have 'fulfilled the dream of Edison'.¹⁹ When B W Reusche & Co (as it seems to have become) advertised its shares it managed to link the blurb to the White Australia Policy in the most tendentious fashion:

hundreds and thousands of new immigrants to this land of MILK and HONEY
WHITE AUSTRALIA IS and EVER WILL BE IF
We bring them here from other Home lands - ENGLAND, IRELAND, SCOTLAND, WALES but
they MUST BE HOUSED.²⁰

There was a flurry of experimental activity in concrete house building in the 1920s and 1930s, especially in Melbourne, and Monolyte was a part of this. The same period saw the introduction or the general acceptance of many of the cement-based products which are now taken for granted. A R Lang's 'monolithic concrete house' at Glen Iris was reported in the *Australian Home Builder* of 1923,²¹ and there were a number of cavity wall systems, discussed below. In 1949 the Builders Steel Form Supply Co Ltd of Richmond, Victoria, claimed that its steel form system had been recognised by contractors for twenty-five years. It consisted simply of steel plates, ribbed on the outer face, supported on a tubular steel framing much like scaffolding.²² By 1954 the company had patents pending for a system of tubular supports, like scaffolding, to hold the formwork panels in place.²³

At an early stage in the development of reinforced concrete a system was devised for building chimneys, using two levels of internal and external circular formwork, successively dismantling the lower ring and reassembling it above.²⁴ This of course assumed that the section would remain unchanged, and the chimney could not have

¹⁶ They resemble those at Leith Avenue, Sunshine, and are also linked with H V Mackay, who acquired the land in 1921-2. It is thought McKay may have built them to accommodate share farmers as part of his plans for improving the Rupertswood Estate. Roser, 'Concrete House in Victoria', p 10, quoting D Moloney & V Johnson, *City of Hume Heritage Study* (1998), BA09, pp 1-5.

¹⁷ 36 King Street, North Fitzroy, which has a flared ring beam at the base of the wall, consistent with details in the patent, and dimensions which are also in accord with it: Roser, 'Concrete House in Victoria', p 11.

¹⁸ *Australian Home Beautiful*, 12 January 1926, p 47.

¹⁹ *Australian Home Builder*, 15 February 1925, p 17. CHECK THIS - Monolyte? date? Reusch?

²⁰ *Australian Home Builder*, 16 January 1927, p 65. CHECK THIS -Reuiche?

²¹ *Australian Home Builder*, November 1923, p 52.

²² F W Ware & W L Richardson [eds], *Ramsay's Architectural and Engineering Catalogue* (Melbourne 1949), § 7/17.

²³ F W Ware & W L Richardson [eds], *Ramsay's Architectural and Engineering Catalogue* (Melbourne 1954), § 7/5.

²⁴ B E [ed] Jones, Cassell's *Reinforced Concrete* (London 1913), p 197.

the customary taper. When sliding form systems, later known as 'slipform', were first used is unclear, but Tall's system or Goddard's cambered concrete might qualify. The question is more one of scale. Concrete silos at Kairi, Atherton and Tolga in Queensland were built by slipform in 1924 by Henry Simon,²⁵ a Manchester milling engineering firm which had established a branch in Sydney in the 1890s.²⁶ It seems likely that other cylindrical silos built by Simons, such as that at Charlton, Victoria, of 1927,²⁷ were in the same system. At another Queensland silo of 1934 it was reported:

The method adopted is known as the sliding form, and every man must be expert at his own particular job. Notwithstanding that the majority of them had to be trained as the work progressed, the last cart of concrete was poured at 4 pm after an aggregate working time of six days, eight hours, and the huge structure weighing 3,000 tons of concrete and steel was practically complete – six bins in seven days.²⁸

In 1937 T Carey claimed to have been the first to use rising formwork for a rectangular reinforced concrete building, the winder house of the Zinc Corporation mine at Broken Hill,²⁹ and this would seem to mark the introduction of the technology in a form applicable to regular building work.

Another system of steel formwork was 'Econo-Forms', in which the steel plates were supported with vertical slotted bars and horizontal linking rods.³⁰ Rather more innovative was the Condeco Mobile Form, which was especially designed to produce cavity walling, and will be referred to below. The Masonite Company produced a form board, which consisted of its standard 'Presdwood' particle board after a further chemical treatment. In the casting of slabs it was supported on timber battens, and in vertical sections it was also backed by timber framing.³¹ From 1956 the Goliath Portland Cement Co was manufacturing permanent formwork sections of asbestos cement, at its plant in Railton, Tasmania. These 'Tasbestos' sections came in a maximum depth of twelve inches [300 mm], and widths of 9, 12, 15 and 18 inches [225, 300, 375, 450 mm].³²

The use of off-form concrete (in architecturally conspicuous locations) possibly arose out of the handcrafted traditions of the British Arts and Crafts Movement. It had been used for houses in the United States at least by 1912,³³ and later more conspicuously

²⁵ Information from Sandi Robb and Justine Thorp, 2007. Simon was one of the overseas engineers who competed to introduce roller milling machinery to Australia, and also contracted for the construction complete mills and silos. However earlier examples of his work, like the W S Kimpton silos in West Melbourne of 1910-11, were conventional brick structures: illustrated in W L Jones, *Where Have all the Flour Mills Gone?* (Melbourne 1984), p 40.

²⁶ Lewis Jones & Peggy Jones, *The Flour Mills of Victoria 1840-1990. An Historical Record* (Melbourne 1990), p 58.

²⁷ Jones & Jones, *The Flour Mills of Victoria*, pp 259-60.

²⁸ An unspecified newspaper report quoted by Justine Thorp.

²⁹ Information from Martin Rowney, Sydney, 1994, citing T Carey, 'Surface Plant at the Zinc Corporation Mine, Broken Hill', *Proceedings of the Australian Institute of Mining and Metallurgy*, new series no 120 [1940].

³⁰ *Ramsay's Catalogue* [1954], § 7/7.

³¹ *Ramsay's Catalogue* [1954], § 7/6.

³² *Tasmanian Architect* [I, c 1963], p 46.

³³ The Mrs Gaston Daus house, Ocean City, New Jersey, by Grant M Simon: M M Sloan, *The Concrete House and its Construction* (Philadelphia 1912), pp 14, 153-4.

at the University of Los Angeles, where a dash coat of stucco was brushed on the exterior carefully, so as not to obscure the formwork marks, and internally the rough surface was stained in decorative patterns.³⁴ But off-form work seems to have appeared in Australia only in 1927 when Rodney Alsop, a Melbourne architect much influenced by the Arts and Crafts movement, won the competition for Winthrop Hall at the University of Western Australia, in conjunction with his employee Conrad Sayce. The colonnade and barrel-vaulted undercroft were constructed of finely detailed board-marked *in situ* concrete.³⁵

It was fifteen years later that the immigrant Swiss architect Frederick Romberg designed Stanhill flats in Melbourne, one of the pioneering essays of European modernism in this country. Wartime and post-war restrictions and shortages delayed the building's completion until 1950, but it was again in an off-form finish, and it presaged the emergence of interest in off-form concrete in the post-war years.³⁶ An eight storey office block in off-form concrete was built in 1959 in Harris Street, Ultimo, Sydney,³⁷ and soon after this the New Brutalist movement made off-form finishes *de rigueur*.

The round columns of Winthrop Hall were also ahead of their time. Octagonal columns had frequently been used by engineers such as Monash and Crawford, but round columns were difficult and expensive to form before the development of cardboard tubes for the purpose. They were nevertheless used by Roy Grounds in his 'Moonbria' flats, 68 Mathoura Rd, Toorak, of 1941, though how the columns were formed in this case is unclear. Another example which seems to have preceded the introduction of the cardboard tube was Harry Seidler's Williamson house, Mosman, Sydney, of 1951.³⁸

b. camerated concrete

Mass concrete was a well-established material for the construction of houses, and there was no obvious reason why it should not continue as such. Nevertheless much of the new technology was immediately adopted for domestic work. One of the more unusual applications of jump form was for walls with inner cavities, apparently formed by removable steel cores. This system, called 'camerated concrete' was developed by Henry A Goddard and patented in 1905, but it seems to be essentially the same as the system patented by Charles Mayes fifty-one years earlier, which has been discussed above. Its first direct application seems likely to have been the world's first reinforced concrete framed factory, the Pacific Coast Borax Refinery at Bayonne, NJ, USA. Here the walls were cast *in situ* sixteen inches [400 mm] thick, and contain cores which increase in size from 10 to 12¹/₂ inches [255 to 312 mm]

³⁴ Portland Cement Association, *Concrete in Architecture* (Chicago 1927), pp 22-6.

³⁵ Tanner, 'Early Reinforced Concrete Frame Buildings', p 56.

³⁶ Tanner, 'Early Reinforced Concrete Frame Buildings', p 41.

³⁷ *Cross-Section*, no 84 (1 October 1959), p 3.

³⁸ Harry Seidler to the Heritage Office, New South Wales, undated but about 16 February 2001.

diameter from the ground to the fourth level.³⁹ Something not unlike it was patented in Canada as late as 1910.⁴⁰

The first examples of camerated concrete to be actually built in Australia were in Ada Street, Concord, opposite Goddard's own house,⁴¹ Michael McCowage of Sydney has identified others at 535 Lyons Road West, Five Dock, and around the corner from this 59 Harris Road.⁴² It seems that some buildings were put up in Tasmania as early as 1906, for within the next few years Goddard sold the rights for the whole of Tasmania and New Zealand, as well as for certain areas of New South Wales.⁴³ The system is reported to have reached New Zealand in about 1907.⁴⁴ There H Leslie Friend of Auckland appears to have been the agent or licensee, and a prominent example was the Sutherland Tannery at Onehunga, Auckland, which was rebuilt in camerated concrete after the original building was destroyed by fire in 1909.⁴⁵ In 1910 the Camerated Concrete Land, Building and Investment Company Limited was floated to acquire some or all of the residual rights.

In Tasmania the system seems to have been used especially by the architect Harold Masters. Masters was the designer of the first Tasmanian example, reputedly either a house at no 3 Lime Avenue, East Launceston,⁴⁶ or one at no 6, built in 1906 for the builder Manser, a partner in Hinman, Wright & Manser.⁴⁷ Jointly with Alexander North he designed another camerated concrete house at 35 West Tamar Road, Launceston.⁴⁸ Three camerated concrete houses were built in Elphin Street (though whether or not by Masters is unclear), and during the next four years about twenty buildings in Launceston, including the Children's Cottage Hospital. St Luke's Church at Zeehan, the west coast, is also thought to be of camerated concrete.⁴⁹ Masters also

³⁹ S E Thompson, *Reinforced Concrete in Factory Construction* (New York 1907), pp 47-55.

⁴⁰ A patent in the name of Donald Hope of Calgary, for a system of moulds to produce hollow walls cast in situ, is reported in the *Canadian Cement and Concrete Review*, April 1910, cited in Thomas Ritchie, 'Notes on the History of Hollow Masonry Walls', *Association for Preservation Technology Bulletin*, V, 4 (1977), p 45.

⁴¹ Untitled mimeographed typescript in the Cement & Concrete Association library, Sydney, containing a list of camerated concrete buildings and other notes; also [Diane Kell], 'Concrete in Australia', special issue of *Constructional Review*, L, 4 (November 1977), pp 24-27.

⁴² Information from Michael McCowage, 1991.

⁴³ Typescript in the Cement & Concrete Association library, Sydney; Kell, 'Concrete in Australia', pp 24-27.

⁴⁴ Jeremy Ashford, *The Bungalow in New Zealand* (Auckland 1994), p 45.

⁴⁵ G W Phillips, *Designs for New Zealand Houses and Residences* (Christchurch [New Zealand], no date [c 1910]), unpaginated. One page shows the Church School at Epsom, Auckland, built of the material, and refers to H L Friend. Another shows the first camerated concrete house built in New Zealand, four weeks into construction. A third shows the tannery, incorrectly identified as 'Sunderland'. Geoffrey Thornton, *Cast in Concrete* (Auckland [New Zealand] 1996), pp 117-8, refers to advertisements for camerated concrete which appeared in *Building Progress* from about the beginning of 1909, referring to W Leslie Friend [CHECK - WL or H L ?]

⁴⁶ Typescript in the Cement & Concrete Association library; Kell, 'Concrete in Australia', pp 24-27.

⁴⁷ Robert & Miranda Morris-Nunn, 'Pure Air and a Lovely Aspect', in Trevor Howells [ed], *Towards the Dawn* (Sydney 1989), p 88.

⁴⁸ Typescript in the Cement & Concrete Association library, Sydney; also Kell, 'Concrete in Australia', pp 24-27.

⁴⁹ Kell, 'Concrete in Australia', pp 26-7: at the time she wrote the cottage was still standing in the grounds of Launceston General Hospital.

designed Dunning & Brown's 'Golden Fleece Emporium' in Brisbane Street, Launceston, which not only was of camerated concrete, but has claimed – most improbably - to have used the first prestressed beams in Australia. This building was demolished in 1954.

Fewer examples of camerated concrete can be identified in other states, but a house at 53 Hewitt Avenue, Rose Park, South Australia, is believed to be built on this system. Later examples of camerated concrete in Sydney include a house at 28 Brady Street, Croydon, and others in the vicinity, believed to date from about 1917.⁵⁰ The system seems to have achieved some vogue in rural New South Wales, and 'Euninindie' homestead at Binalong is built of it,⁵¹ while in Moree a row of shops which seem to be of camerated concrete were built by a prominent citizen and mayor of the town, Andrew Percy Mellor, possibly in about 1920.⁵²

c. cavity walling

Although 'camerated concrete' with tubular cavities is reasonably well documented, the appearance of the full cavity wall in concrete is a little mysterious. In 1907 the American architect Grosvenor Atterbury developed a system of hollow-cored factory precast concrete panels for use in walls, floors and roofs,⁵³ and this was used by the Russell Sage Foundation in 1913-18 for a low cost housing development in Forest Hill. The system ultimately failed because of the high cost of transporting the components to the site, and little else in the way of precasting occurred overseas prior to World War II.⁵⁴ While this may have had some influence in Australia, it appears to have been preceded by local cavity systems constructed *in situ*.

A hollow concrete wall system was patented in Victoria in 1907 by H R Crawford,⁵⁵ who built houses on this system in Canterbury and East Camberwell, and in 1912 one for himself, which it still stands at 1121 Dandenong Road, East Malvern.⁵⁶ The Methodist church at Carngham, Victoria, of 1908, was reported to be the first building of its kind to have hollow walls,⁵⁷ and may well be an example of Crawford's system, as may a house at Whitfield, believed to date from 1910. At Whitfield the walls appear to about 280 mm or a nominal eleven inches thick, comprising inner and outer leaves each of about 90 mm, inclusive of the external render and the internal plastering respectively, with a cavity of about 100 mm. Some pieces of galvanised wire are visible, and the material may have been used both to reinforce the concrete and to connect the leaves together.⁵⁸

⁵⁰ Information from Michael McCowage, 1993.

⁵¹ Kell, 'Concrete in Australia', p 27.

⁵² In Barlow Street, Moree, with the word 'Mellor's' still visible on the parapet. Reported by Helen Wilson.

⁵³ Bemis, A TO COMPLETE

⁵⁴ A L Carr, *A Practical Guide to Prefabricated Houses* (New York 1947), p 8.

⁵⁵ No 9135 of 6 July 1907, ref *Building* (September 1907), p 37.

⁵⁶ My information derives from Crawford's grandson, Mr Bruce Nixon of Yarra Glen. Dr D R Macdonald has kindly permitted inspection of the house at East Malvern.

⁵⁷ *Building*, 16 November 1908, p 21.

⁵⁸ House on Neil Sheppard's property, Whitfield, brought to my attention by Carl Doring and Deborah Kemp, and inspected externally, January 2000.

The Tasmanian architect Harold Masters, a major user of cambered concrete, seems to have used a full cavity wall in his house for A Brown at Longford, also in about 1910.⁵⁹ It still stands diagonally opposite the State School, and there are other concrete houses by him in the area which may well be of the same construction. Masters was also to design the reinforced concrete powerhouse at Longford in connection with his scheme of electrification for the area.⁶⁰

In 1922 the N.S.W. Concrete Co. Ltd. was building houses at Belmore, Sydney, using steel shuttering on the Wilson patent system, under the supervision of D J Hutchings, who was manager of the patent rights (and formerly Deputy Commissioner of Patents for New South Wales). It appears, from a letter of the architect John Sulman, that these were in fact war service homes. A light frame was built of steel angle uprights, and Ts at the wall junctions, tied across at the top. The footings were put in, and then the steel shuttering used to continue the walls upwards, using 'an ingeniously contrived cavity box' to keep the outer walls hollow, six inches [150 mm] thick in two leaves of 2¹/₄ inches [56 mm] with a continuous 1¹/₂ inch [38 mm] cavity, bridged only with kinked wire wall ties. The internal partition walls were solid and 75 mm thick. The concrete contained bluestone aggregate, though Sulman expressed the opinion that coke breeze would be just as good provided that the minimum leaf thickness was increased to 75 mm and it was reinforced vertically with ¹/₄ inch [6 mm] rods and horizontally with 8 gauge [4 mm] wire. Sulman had been prevailed upon, or paid, to write to the company describing it as 'the most practical system of concrete house construction which has come under my notice', and saying that he thought the houses at Belmore 'stronger, more durable and weatherproof and easier to erect than the ordinary brick cottages built with 12" hollow walls.'⁶¹

By 1923 the Wilson patent system was apparently controlled by Co-Operative Estates Ltd of Pitt Street, and - presumably for some further consideration - Sulman wrote the same letter to the manager of that company.⁶² There is no documentary evidence of the use of this method in Victoria, but there is a surviving Melbourne suburban house with walls that appear to be on this or a similar system.⁶³

In about 1928 W Pearce patented a system of cavity walling using poured concrete, and

vertical studs with horizontal bars on inner face - metal mould sheets attached. Bracing bears against the sheets. Hollow walls are formed by means of a frame having side and bottom battens braced and supported on bolts or ties projecting through a previously erected wall, the mould sheet being attached to the face thereof and held against contact with the existing wall at top and bottom by loose distance fillets.⁶⁴

⁵⁹ *Building*, 12 November 1910, pp 80, 84, 86.

⁶⁰ Information from Caroline Miley, Melbourne, 1988.

⁶¹ *Building*, 12 May 1922, pp 81-3, 107, 109, 111 & 113.

⁶² John Sulman to the Manager, Co-Operative Estates Ltd, 26 September 1923, copy from the Stonnington City Archives, courtesy Di Foster.

⁶³ 'Thurston', 25 Hoddle Street, Caulfield, said to be c 1927, but seemingly Edwardian in style.

⁶⁴ Patent 8083: *Building and Construction*, 10 April 1928, quoted in Paul Roser, 'Concrete House in Victoria', p 12.

Paul Roser has identified a house built by a W Pearce, presumably the same man, in the Melbourne suburb of Richmond, but it has been demolished and we do not know whether it was built on this system, especially as it dates from 1926, prior to the patent.⁶⁵

E W Rose invented about 1926⁶⁶ and patented no later than 1933, a system which produced cavity walls, cast in-situ with reusable modular formwork and, as it developed, suspended concrete floor slabs as well. For an ordinary suburban house the whole of the external and internal walls could be poured in one operation.⁶⁷ The formwork panels were of oregon, held in place by an adjustable framework of mild steel. The two leaves were three inches [75 mm] thick with a 5½ inch [140 mm] cavity.⁶⁸ The system was used in New South Wales and Victoria, most notably in the Zegellin house near Rochester, Victoria, completed in early in 1941 to the design of L Hume Sherrard. At Goulburn, New South Wales, a building society promoted the system for use by its members, but it seems that the economies effected by it were slight, and it was only Rose's enthusiasm which kept it alive so long.⁶⁹ Rose's system fell into desuetude during World War II, but in about 1947 a new house was built for Rose himself in the Melbourne suburb of Reservoir, and again to a design by Sherrard.

The Australian invented 'Condeco Mobile Form' appeared in the 1950s. It was made of aluminium and seems to have allowed for casting one course in height (perhaps six inches, or 150 mm) at a time. It appears to have consisted essentially of two strips of this dimension, connecting clamps and, where necessary, a core to form a cavity.⁷⁰ The maker, Durabild Pty Ltd, was Melbourne-based, and in New South Wales the system was marketed by Ernest Child & Son of Sydney, and later by W R Tresize Ltd of Lismore.⁷¹

d. L M Perrott

Leslie M Perrott had been designing concrete houses since the end of World War I.⁷² He began to publish articles on the topic in the 1920s.⁷³ These articles describe some

⁶⁵ Roser, 'Concrete House in Victoria', p 12, quoting *Suburban Building Record*, 9 March 1926.
⁶⁶ 'Concrete Houses', *Australian Housing Bulletin*, 8, May 1946, pp 66-7, quoted by Roser 'Concrete House in Victoria', p 12.
⁶⁷ W A Somerset, 'New Ideas in Concrete Home', *Australian Home Beautiful*, XXVI, 10 (October 1947), p 7.
⁶⁸ 'Concrete Houses', *Australian Housing Bulletin*, 8, May 1946, pp 66-7, quoted by Roser 'Concrete House in Victoria', p 12.
⁶⁹ Peter Cuffley, *Australian Houses of the Forties and Fifties* (Knoxfield [Victoria] 1993), pp 64-5, quoting the *Australian Home Beautiful*, March 1941.
⁷⁰ *Ramsay's Catalogue* [1954], § 7/8.
⁷¹ George Topham, *Be Your Own Builder* (Sydney 1952), facing p 73; *Australian Home Beautiful*, February 1956, p 78.
⁷² *Real Property Annual*, 1919, pp 28-9.
⁷³ L M Perrott, 'Design in Concrete Construction', *Australian Home Builder*, November 1923, illustrating houses in Bayswater and Brighton. His 'Concrete for Home Building', *Journal of the Royal Victorian Institute of Architects*, March 1932, pp 7-8, illustrates the house of Mrs C R Fennes, Marne Street, South Yarra.

of his concrete buildings, and the *Home Builder* in 1925 reported on his designs for reinforced concrete cottages in East Camberwell.⁷⁴ Perrott became a great protagonist of reinforced concrete: he somewhat unprofessionally added the words 'concrete for permanence' to his letterhead, and in 1925 published a book *Concrete Homes*⁷⁵ containing designs which, in the absence of the title, would never be taken for anything other than conventional construction. Some which survive, and have been identified by Paul Roser,⁷⁶ are 377 Barkers Rd, Kew of about 1925; 'Maplewood', 123 Wattle Valley Road, Camberwell, also about 1925; and 'Arrodene' at 3576 Nepean Highway, Portsea, where local limestone was used as aggregate.

At least some of Perrott's houses must have been of 'Steelcrete', A set of photographs (undated, but apparently of the early 1920s) survive to illustrate what must have been the flagship house built on this system, and it carries a board identifying it as a Steelcrete building, with Leslie M Perrott of Collins Street as the architect, and J & T Muir of Leveson Street, North Melbourne, as the builders. The house appears to be built on a lightweight steel frame, joined with what may be clamps, looking rather like scaffolding. The frame has a horizontal top and bottom plate, between which run light vertical rods which pass through the top plate and are bent over. These rods are spaced fairly closely, perhaps as little as 200 mm, and are progressively encased from bottom up in solid cast concrete.⁷⁷ In overall appearance this very much resembles the Wilson system, being used in Sydney at about the same time. However the Wilson system relied upon moveable steel shuttering while Steelcrete appears to have had no shuttering, so that the cement or concrete must have been applied by hand.

The term 'Steelcrete' as used here appears to be entirely unconnected with the 'Steelcrete' brand of Steel and Radiation Limited of Toronto, Canada. The Canadian firm appears to have marketed a combination of expanded metal and 'Klutch' bar reinforcement, or occasionally other rods, round, square or twisted.⁷⁸

e. concrete veneer

In April 1937 it was reported in Auckland that E G Forster, of the suburb of Bayswater, had been granted a patent for his invention of concrete veneer. It was described as being similar to brick veneer, and seems to have been little more than a streamlined means of casting a leaf of concrete on the outside of a timber carcass. It used a framework of 3 x 2 inch [70 x 50 mm] studs on the flat, spaced at three foot [900 mm] centres, to take the inside shuttering for the concrete leaf. Intermediate studs were to be inserted after the shuttering was removed.⁷⁹ The thickness of the concrete seems to have been four inches [100 mm] and the system used special ferrules and cramps which could only be obtained from the patentee.⁸⁰

⁷⁴ *Australian Home Builder*, 16 June 1925, p 55. CHECK DATE.

⁷⁵ L M Perrott, *Concrete Homes* (Melbourne 1925).

⁷⁶ Roser, 'Concrete House in Victoria', p 13.

⁷⁷ Photographs in the possession of Allan Willingham, Victoria.

⁷⁸ Steel and Radiation Limited, *'Steelcrete' Expanded Metal and 'Klutch Bar' Concrete Reinforcement* (Toronto, no date [c 1910]), passim.

⁷⁹ *Building Progress* [Auckland], II, 4 (April 1937, Christchurch ed), pp 16-17.

⁸⁰ *Building Progress* [Auckland], II, 5 (May 1937, Wellington ed), p 16.

Immediately before World War II the Tasmanian government was building houses in 'concrete block veneer',⁸¹ but seems to have differed entirely from the New Zealand system, and more resembled the 'masonry veneer' much used for school and hospital buildings in Victoria in the 1950s and 1960s. This consisted of thin slabs or tiles of concrete with projections on the back by which they could be hung onto a conventional timber stud frame. Their appearance (so long as the timber frame did not distort) was that of conventional concrete blocks. The principle was pretty much that of the English 'mathematical tiles', though the nearest precedent in Australia was probably Walter Taylor's system of hanging concrete facing panels onto a concrete stud frame. In Victoria the Nunawading Timber Co was a major supplier and fixer of the material, which it advertised in both cream and grey.⁸²

f. concrete roof tiles

Concrete ridging tiles of his own design seem to have been used by J H Hunt as early as 1883, on the slate roof of the Andrew Broad house in Croydon, Sydney.⁸³ It is surprising therefore that concrete roofing tiles were first made in England only in 1893.⁸⁴ They were reportedly made in New Zealand by W T Cowperthwaite from 1904, though it was perhaps slightly later than this.⁸⁵ In Australia they were made by 1903 at the Federal Building Material Company's works in South Melbourne, 'in any decorator colour'. The company would also supply patent machinery for making roofing tiles, to any part of Australia.⁸⁶ In 1918 Robert Law's Monier Patent Company began to make concrete tiles in Western Australia,⁸⁷ and in the East W B Griffin devised a special form of tile for his Knitlock construction system. These measured 300 mm square and were laid in a diagonal pattern,⁸⁸ but of course they had no impact upon the market as a whole.

In the 1920s small quantities of concrete roofing tiles apparently began to be made in imitation of the Marseilles pattern which had proved so successful in terra cotta.⁸⁹ Soon after the war the Federal Roofing Tile Company was producing concrete roofing tiles, apparently of a pattern similar to the Marseilles, in grey, green and slate

⁸¹ F O Barnett & W O Burt, *Housing the Australian Nation* (Melbourne 1942), p 80.

⁸² Nunawading Timber Co. Pty. Ltd., *Masonry Veneer* (Blackburn [Victoria] no date [c 1950 ?]); Nunawading Timber Co. Pty. Ltd., *Ready Cut Homes* (Blackburn [Victoria] no date [c 1950 ?]). The latter, despite the title, also includes material on masonry veneer.

⁸³ Peter Reynolds & Joy Hughes, 'Private Practice: Works 1869-1904', in Peter Reynolds, Lesley Muir & Joy Hughes [eds], *John Horbury Hunt: Radical Architect 1838-1904* (no place [Sydney] 202), p 124

⁸⁴ Marian Bowley, *Innovations in Building Materials* (London 1960), pp 84, 263, quoting Dobson, *History of the Concrete Roofing Tile*.

⁸⁵ W T Cowperthwaite's obituary states that he produced cement tiles from 1904, but dates the foundation of his firm in Auckland to 1908: *Building Progress* [Auckland], II, 8 (August 1937), p 19. His son A B Cowperthwaite joined the firm in 1918: *Building Progress*, VIII, 1 (January 1943), p 16. See also Jeremy Ashford, *The Bungalow in New Zealand* (Auckland 1994), p 46.

⁸⁶ *Building, Engineering and Mining Journal*, 18 April 1903, supplement p 2.

⁸⁷ Bryce Moore, *From the Ground Up* (Nedlands, WA, 1987), p 48.

⁸⁸ D L Johnson, *The Architecture of Walter Burley Griffin* (South Melbourne 1977), p 58.

⁸⁹ Robin Boyd, *Australia's Home* (Melbourne 1952), p 153.

colour,⁹⁰ and the Rolyat works in Neerim Road, in the Melbourne suburb of East Caulfield, produced a simplified Marseilles pattern in a red colour.⁹¹ Rocla were advertising concrete roofing tiles in 1927 though they are not illustrated or described,⁹² and in 1928 there were nine suppliers of concrete roof tiles listed in Melbourne.⁹³

All of this was apparently at a relatively small scale, but there was a proliferation of small manufacturers and a great increase in output in the later 1940s, after which the industry began to convert to mechanised processes.⁹⁴ Peter Cuffley describes how his grandfather conducted a backyard tile factory from about 1946. The tiles were moulded to a pattern resembling the Marseilles, turned out of the mould when set but not dry, given a coating of powdered colour on one side, and put on racks to dry.⁹⁵ A production of about ten thousand tiles a day was the level at which automatic machinery became economic,⁹⁶ but the basic phases of manufacture remained the same. In 1948 the *Australian Standard Specification and Code for Interlocking Tiles* were revised and published under one cover, both now limited to Marseilles pattern tiles. References in earlier editions to shingle and Latin tiles were omitted, though it was envisaged that separate specifications for these types might be brought out later.⁹⁷ By 1949 the only concrete tiles listed in *Ramsay's Catalogue* were 'Atlas', made by the Cindcrete Brick Co (Swanton & Barrett Pty Ltd) of Port Melbourne.⁹⁸ But in 1954 Concrete Industries were advertising their Monier Roofing Tiles, in eight integral colours.⁹⁹

g. W H Lascelles

The pioneer of precasting on a systematic basis was the London builder W H Lascelles, whose influence in Australia was to be substantial.¹⁰⁰ In 1875 he

⁹⁰ *Everyman's Home*, III (October 1922), p 51; see also L M Perrott, *Concrete Homes* (Melbourne, no date [1925]), unpaginated.

⁹¹ The Neerim Road address is from directories. Samples of the tiles themselves have been accessible during the 1998 reroofing of building 157 at Melbourne University, apparently built in the 1920s as a caretaker's house in connection with the Raymond Priestley Building.

⁹² Royal Victorian Institute of Architects, *International Architectural Exhibition June 7th to 11th, 1927* (Melbourne 1927), p 32.

⁹³ J S Gawler, *The Architects' and Builders' Index (Victorian Edition)* (Melbourne 1928), p 45.

⁹⁴ [Diane Kell], 'Concrete in Australia', special issue of *Constructional Review*, L, 4 (November 1977), p 43.

⁹⁵ Peter Cuffley, *Australian Houses of the Forties and Fifties* (Knoxfield [Victoria] 1993), pp 19-20.

⁹⁶ R H Baumgarten & H L Childe, *Manufacture of Concrete Roofing Tiles* (2nd ed, London 1947 [1936]), p 30.

⁹⁷ The specification is A.14-1948 and the code CA.6-1948: *Commonwealth Engineer*, 1 May 1948, p 3.

⁹⁸ W L Richardson & F Wentworth [eds], *Ramsay's Architectural and Engineering Catalogue* (Melbourne 1949), § 10/4. Examples of the tiles, from a later rear wing of building 157, Melbourne University, referred to above, have been found to bear an Australian patent number, 105,651.

⁹⁹ *Ramsay's Catalogue* [1954], § 13/2.

¹⁰⁰ Quite apart from his concrete building system, Lascelles negotiated with the Victorian Government in the 1870s to supply wooden buildings based upon Colibert's *maison d'abri*, though this plan did not ultimately proceed.

developed his Patent Concrete Slabs,¹⁰¹ and began to market these for the use of builders and amateurs. The slab was typically three feet long by two feet [0.9 x 0.6 m] high by 1.5 in [38 mm] thick (or one inch [24 mm] for lining slabs), and reached its greatest glory in what was called the Fish-scale Tile Slab (though it was actually a somewhat different ornamental pattern). This was in imitation of the tiles commonly used for cladding vertical surfaces, the verisimilitude being maintained by the addition of red pigment. The slabs generally were rebated at the bottom and tapered to the top so that each course lapped the top of the one below, and were used in conjunction with concrete studs with a rod through the centre and measuring 2.5 m long by 102 mm square, the same members being used for floor joists, foundation sleepers, and sill and lintel pieces, though it was possible to replace them with timber. The slabs themselves, at least in their plainer varieties, were also usable as roofing. The studs were at three foot centres to suit the slab dimension, and the slabs had to be drilled so that they could be screwed onto this frame. The roof could be formed of slabs in a similar way.¹⁰² Lascelles appears as a portable house builder in the *London Post Office Directory* for 1889. A surviving example of his work, discovered in the 1990s, was the Central Buffet and Dock Manager's Office at the Royal Albert Dock.¹⁰³

The best-known structure on Lascelles's system was the Jury House at the Paris Exposition of 1878, designed by Norman Shaw, which was distinguished by the fact that everything was done to make it seem *not* to be of concrete. The material was dyed red to simulate brick or tile, and the design was in a sort of classicising Queen Anne manner. Although Lascelles was Shaw's favoured builder, it seems that in this instance builder was probably the patron, commissioning Shaw to give a favourable aesthetic spin to his new product. The reason for believing this is that there was published concurrently, under Shaw's name, a manifestly promotional work called *Sketches for Cottages and Other Buildings designed to be Constructed in the patent cement slab system of W H Lascelles*,¹⁰⁴ which is remarkable for the fact that the designs are of a uniformly picturesque and eclectic character, once again conveying no hint that they are of concrete slabs, but instead the appearance (at least in the published designs) of brickwork, tile hanging and stucco).

There are two ways in which this system became known in Australia, though it is impossible to identify any actual example of its use in this country. The first is that it was exhibited at the Sydney International Exhibition in 1879-80, by J R Cattell & Co,

¹⁰¹ British patent no 2151, W H Lascelles, 'Constructing Buildings', 1875, cited in B L Hurst, 'Concrete and the Structural Use of Cements in England before 1890' [reprint from *Proceedings of the Institution of Civil Engineers: Structures and Buildings*, special issue, *Historic Concrete*, 116, issue nos 3-4 (August-November 1996)], in Frank Newby [ed], *Early Reinforced Concrete* (Aldershot [Hampshire] 2001), p 40, note 42.

¹⁰² [Francis Young], *Every Man His Own Mechanic* (London, no date [c 1882 (?c 1875)]), pp 582-594. B E Jones, *Cassell's Reinforced Concrete* (London 1913), p 8, refers to W H Lascelles as experimenting at Croydon in 1877 with a system of cottage building based on his earlier patents and using a timber framework in conjunction with slabs of concrete reinforced with diagonal rods.

¹⁰³ Hurst, 'Concrete and Cements', p 38.

¹⁰⁴ Norman Shaw, *Sketches for Cottages and Other Buildings designed to be Constructed in the patent cement slab system of W H Lascelles* (London, no date [1878]).

who were the agents for New South Wales.¹⁰⁵ The second is that it was published locally at about the turn of the century in *The Australian Amateur Carpenter and Builder*,¹⁰⁶ which was in fact a literal reproduction of the English work, *Every Man His Own Mechanic*, but camouflaged for Australian consumption. It must be conceded that the Lascelles system is of dubious practicality. But the fact is that it was very well-known, and must inevitably have influenced later methods of precast concrete construction, especially those based upon a frame clad in concrete planks, such as are found later in both Britain and Australia.

In Britain the 'Duo-Slab' system of William Airey & Son came into use in the Leeds area at some time prior to the report of the Standardization and New Methods of Construction Committee in 1920. It consisted essentially of concrete columns at four foot [1.2 m] centres, clad on both faces with concrete planks measuring eight inches by four feet [200 mm x 1.2 m].¹⁰⁷ The Boot system, of about 1925, used precast concrete columns at three foot [0.9 metre] centres, clad on both sides with clinker concrete slabs nine inches [225 mm] high, the piers being tongued and the slabs grooved. Between 1926 and 1930 more than eight thousand of these houses were built in Britain.¹⁰⁸

h. precasting

The American system developed by Grosvenor Atterbury in 1907 has been mentioned in the context of cavity walling, but no precast system related to it has been identified in Australia. The earliest local system was put forward by Newton in 1881, and used 1½ inch [38 mm] thick concrete panels set in timber frames, and carried on concrete studding.¹⁰⁹ The more ornamental forms such as Benedict Stone and 'precast stone' are discussed below, but here we are concerned with more structural applications.

E G Stone's patent of 1909¹¹⁰ was concerned with curved precast slabs for the construction of silos, but he used flat versions of what is unmistakably the same system for a cottage at 2 Railway Street, Emu Plains, New South Wales, in 1909. Other concrete buildings followed, but it is not yet possible to be certain which were constructed on his patent system and which were not.¹¹¹ Stone's slabs were panelled, and had closed hooks or loops projecting along the sides, so that when rods were

¹⁰⁵ Sydney International Exhibition 1879, *Official Catalogue of the British Section* (London 1879), p 51; *Town and Country Journal*, 28 February 1880, p 405. It is interesting to note that the exhibit was credited jointly to W H Lascelles and to John Bazley White & Bros, the leading cement manufacturers.

¹⁰⁶ [Francis Young], *The Australian Amateur Carpenter and Builder* (Sydney, no date [c 1900]), 'General Building Art and Practice', pp 87-98.

¹⁰⁷ *Standardization and New Methods of Construction Committee. Report of the First Year's Work of the Committee* (1920), cited by R B White, *Prefabrication. A History of its Development in Great Britain* (London 1965), pp 54-5 & plates 3.19-3.21. See also John Gloag & Grey Wornum, *House out of Factory* (London 1946), p 44.

¹⁰⁸ White, *Prefabrication*, pp 57-8.

¹⁰⁹ *Australian Engineering and Building News*, 1881, p 199, cited Hanut Dodd, 'Lime and Victorian Buildings' (MPD, University of Melbourne, 1997), p 99.

¹¹⁰ Patent application no 14,486 of 11 May 1909.

¹¹¹ See Miles Lewis, 'Concrete from Stone', *Australian Institute of Building Papers*, III (1988-9), pp 169 ff.

dropped vertically through these, and the joint was grouted, the adjoining panels were locked together. The horizontal joints were bolted and grouted.¹¹²

Another system consisted of panels which could be used in external walls, and was known as 'Patent Reinforced Cement Walling'. It consisted of units, typically 3 ft 6 in by 10 or 11 feet high [1.05 x 3.0 to 3.3 m], framed in light steel angle with cross bars, and sheeted in any of the metal lathings such as expanded metal, Clinton Fabric &c. The frames were laid on a table, filled with concrete and tamped solid. In the process of erection they were bolted together and then the access holes to the bolts filled and stopped with concrete.¹¹³

In a world context the 1920s is said to have been the decade in which load-bearing panel systems, in the form either of pans or trays, came to prominence.¹¹⁴ One such system, somewhat similar to Stone's in its use of projecting ribs, has been identified in a house, 'Ambleside', at 7 Windermere Avenue, Northmead, outside Sydney, which is thought to date from about 1917-22. It is not built on a coherent system, but appears to have been assembled out of panels recycled from elsewhere, some of which are also laid as verandah paving. The wall panels are partly buried, to an unknown depth, but the exposed height is about 3.07 metres, the width 1.2 metres and the thickness about 50 mm, with projecting ribs on the outer face. The ribs along the vertical edges are very deep (about 240 mm), and abut each other to form substantial columns. There are shallower horizontals at top and bottom, and the panel is further articulated at mid-point, both vertically and horizontally, by slender ribs of the shallower depth (about 130 mm).¹¹⁵ The overall appearance is somewhat reminiscent of the Geelong Cement Works house, which has been mentioned above, though that is not thought to have been precast.

The Queensland Railways seem to have pioneered the use of precast horizontal slabs fitting into precast grooved posts, which was used for Kuranda railway station in 1915.¹¹⁶ Though the origins of the system have yet to be established it is distinctly reminiscent of that of the London builder W H Lascelles in the nineteenth century. The same system as in Queensland, or something very like it, was adopted by the New South Wales Government Railways in 1917, and used to construct 140 stations over the next fifteen years, together with other buildings. In 1919 it was reported that the 'ferro-concrete system' had been widely used for signal boxes, battery cabinets, &c.¹¹⁷ The system has continued in use almost to the present day, and used 150 mm square posts at about one metre centres, grooved to receive 250 x 50 mm planks, formed to give a flat finish internally and drafted joints externally, like Queensland

¹¹² E G Stone, *Reinforced Concrete Construction in Australia* (Sydney 1920).

¹¹³ C E Mayes, *The Australian Builders & Contractors' Price Book* (8th ed, Sydney 1914), pp 240-1.

¹¹⁴ Gloag & Wornum, *House out of Factory*, p 44.

¹¹⁵ Personal inspection, and photographs and sketch supplied by Greg Patch, October/November 2000. According to Patch, William Bowes bought the land in 1911 and surveyed it for subdivision in 1917, but some of the panels are found on the boundary of a lot surveyed only in 1922, which may suggest this as the earliest possible date. Bowes lived there until his death in 1929.

¹¹⁶ Miles Lewis, *Two Hundred Years of Concrete in Australia* (North Sydney 1988), pp 22-3.

¹¹⁷ C & M J Doring Pty Ltd & Gardner Brown Planning Consultants, 'Broadmeadow Locomotive Depot Heritage Study' (Sydney 1995), p 191.

chamferboard. One extant example is in Fairfield Road, Yeerongpilly.¹¹⁸ There is also a concrete plank floor structure, but the roof is timber framed.¹¹⁹ Another example is the North Barracks of the Broadmeadow Locomotive Depot, of 1923-4.¹²⁰ In 1927 the Katherine railway station in the Northern Territory was built in a similar fashion, as are some structures in the Victorian Railways. In Sydney Michael McCowage has identified four houses of this type of construction at 58-64 Henry Street, Five Dock, and they look as if they might date from about 1915 [CHECK].¹²¹

In 1922 A C Matthews of Melbourne developed a system of building cavity walls using precast concrete sections, the outer skin of dense well-rammed concrete, and the inner of coke breeze. The walls were 'tied together with steel reinforcement, held in position by the plastic concrete which is poured down the column cavity ... the precast units entirely eliminate the forms ...'.¹²² This would seem to closely resemble the principle of Griffin's Knitlock, and especially his 'vertebral' columns.

The Brisbane engineer Walter Taylor built shops, houses and a church at Graceville, Brisbane, consisting for the most part of concrete slabs fixed over a concrete frame.¹²³ They are mostly undated, but the system probably evolved after 1913, when he built his own house of conventional construction, apparently of coke breeze block and brick,¹²⁴ and certainly before 1927 when the church was built. Michael McCowage reports a building of the same or similar construction, now used by the Railways as an office, near the corner of Fairfield Road and Chale St [CHECK].¹²⁵ Another house by Taylor of about 1912-13, at 120 Chelmer St West, Chelmer, is described as being of three inch cavity concrete blocks, succoed externally, on concrete piers and with reinforced concrete bearers under the exterior walls only.

There are some variations between the examples of Taylor's slab system, but eliding what can be seen in three of the more accessible ones, there are 150 x 300 mm [6 x 12 inch] concrete stumps, across which spans a 100 x 60 mm or 110 x 50 mm steel channel on edge, with its open face inwards. On top of this channel stand 110 x 50 mm concrete studs at rather more than 600 mm [2 ft] centres, to the face of which are attached 312 x 615 x 60 mm thick slabs in the vertical direction. These horizontal joints are tongued and grooved, with the tongue pointing upwards, and are chamfered on the faces to give a V joint. Where the slabs are exposed internally, as at 333 Honour Road, the joint is pointed up flush. There are V joints in the vertical direction as well, but the internal section was not apparent from inspection. The bottom row of

¹¹⁸ This is at the corner of Chale Street, opposite Palomar Street, and currently labelled 'Infrastructure Engineer's Office': information from Michael McCowage, 1995.

¹¹⁹ Graham Holland, 'Pre-Cast Concrete Railway Stations in NSW: a Preliminary Report', in P-A Johnson [ed], *SAHANZ 87 Papers* (Kensington [New South Wales] 1991), pp 21-5.

¹²⁰ Doring & Gardner Brown, 'Broadmeadow Locomotive Depot Heritage Study' p 192.

¹²¹ Inspected with Michael McCowage of Sydney, 1994.

¹²² *Australian Home Builder*, August 1922, p 75; March 1924, p 41; *Australian Home Beautiful*, 1 June 1927, both cited in Paul Roser, 'Concrete House in Victoria', p 18.

¹²³ I am much indebted to Michael McCowage for my initial information about these buildings, leading to a superficial inspection in 1993.

¹²⁴ 15 Molonga Terrace, nw corner Kianga Road, inspected courtesy of Mrs Rhonda Johnson, who also provided information.

¹²⁵ Information from Michael McCowage, 1995.

slabs hangs below the bottom of the studs, so as to conceal the steel channel from view.¹²⁶

The Methodist church at the corner of Oxley Road and Verney Street is a wonderful structure, of 1927, with Gothic windows, buttresses, a bracketed eave and fretted parapet, a tower and spire, and a pinnacle carried on flying arches over a polygonal chamber at one corner. But the wall units are the same as in the other buildings, and the adjoining Memorial Hall was built in a similar way twenty years later.¹²⁷ An architect's report on the church in 1957 seems to indicate that the whole of the timber flooring is in bays ten feet [3 m] square. It points to many defects in the original structure, and others which had arisen subsequently, but sheds little further light on Taylor's basic system.¹²⁸ A stylistically later house, apparently of the at least the 1930s, is at 91 Ardoyne Road, Oxley, clad in the same panels, including the basement level and the curved corners of the projecting front bay.¹²⁹

Michael McCowage has discovered a house at 20 Brady Street, Croydon, Sydney, which cannot be precisely dated but is of an interesting precast construction. The panels are vertical and fit together with tongued and grooved vertical joints, each panel containing two rectangular voids running up its length.¹³⁰ This may relate to a system which was developed by the Experimental Building Station in the 1940s, in which the basic component was a vertical panel measuring 9 ft by 1 ft 6 in [2.7 x 0.45 m], designed for the walling of single storey houses. A number of other precast units were involved as well, including beams, stumps, plinths, spandrels to go below windows, corner sections, &c.¹³¹ A more radical Australian development was the spun concrete pipe developed by the Hume brothers of Adelaide, out of the spray painting apparatus which they had used to treat their rolled steel fences. This invention was taken up across the world.¹³²

John Harris, who had first come to Australia to establish the Freyssinet system locally, joined the engineer W P Brown in Melbourne in 1951 to establish England Pipe and Marlite Ltd, soon to become E.P.M. They manufactured pipes, washtubs and paving flags. In 1953 they began mould pre-tensioning and steam curing, and produced what were possibly Australia's first exposed aggregate panels, for the

¹²⁶ The stump and the 60 x 100 mm channel were measured at 4 Rakeevan Road; the stud and the 50 x 110 mm channel at 9 Molonga Terrace, and the cladding blocks at the shop, 333 Honour Road, sw cnr Rakeevan Road. Other buildings in the group are 8 Rakeevan Rd; 'Kimbar' at 23 Molonga Terrace, sw corner Kianga Road, where there is at least some in situ concrete; 95 Bank Road, which seems to have been built shortly after his own house and also to pre-date the system, being partly of concrete block and partly weatherboarded, probably with some reinforced concrete framing. 4 and 8 Rakeevan Road have a fence which seems to be monolithic, but faced in the standard blocks as permanent formwork.

¹²⁷ These buildings are datable from foundation stones.

¹²⁸ Cook & Kerrison [architects] to the Secretary, Trustees of the Methodist Church, Graceville, 26 March 1957: copy from the parish records kindly supplied by Mrs Margaret Pullar of Brisbane, 1996.

¹²⁹ Information from Michael McCowage, 1997.

¹³⁰ Information from Michael McCowage, 1996.

¹³¹ Nelson Lemmon [Minister for Works and Housing, Australia], *About Housing* (Canberra 1947), p 67.

¹³² See, for example, Faber & Childe, *Concrete Yearbook 1949*, (Canberra 1947), p 957, where Teign Valley Concrete, of Devon, advertises Hume Centrifugally Spun Pipes..

Melbourne Grammar boatshed.¹³³ Part of the rationale for the building was that the land faced possible resumption by the Melbourne City Council, so the structure was designed to be demountable, with the panels simply clipped onto the frame. A more general issue which arose at the Bromby Street building of Melbourne Grammar (by the same architects, Mockridge, Stahle & Mitchell) was that the regulations offered the choice of filling the spandrel below the windows in eleven inch [275 mm] brickwork or 1.1/2 inch [38 mm] precast panels with six inches [150 mm] of terra cotta lumber behind,¹³⁴ which tended to encourage the use of the precast elements. Oddly enough, full height glass would have been equally acceptable.

In 1954 EPM was advertising jointly with SVC - Specialised Vibrated Concrete - as if they were one company, offering precast concrete fencing in two models, a park type with a square rail on the diagonal, resting on top of square posts, and a residential type with two plank like rails fixed to one face of the posts. It seems that the actual manufacturers were probably SVC, of West Brunswick,¹³⁵ but some particularly crisply cast fence posts and rails bearing the mark 'EPM' and the brand 'Four-in-One' have been reported at Christmas Hills near Melbourne.¹³⁶ Others are reported at the former Mont Park farm, now part of Latrobe University.¹³⁷ In 1960 EPM Concrete (NSW) was established, with the Victorian company owning 20% of the shares, but the Victorian company was soon afterwards bought out by ARC, which then acquired the balance of the New South Wales one as well.¹³⁸

Meanwhile in 1953 Concrete Industries, South Australia, Pty Ltd, bought the plant and buildings of the South Australian Portland Cement Company at Brighton, to establish there a plant for making precast hollow beam flooring and various prestressed items.¹³⁹ In 1954 *Ramsay's Catalogue* illustrates (in addition to the Monier and EPM prestressed products) Monier 'Hollowbeam' flooring, consisting of rectangular beams with oval cores, which were placed side by side to create a continuous slab, and a number of more elaborate panels and beams by the Melbourne company Bucklands.¹⁴⁰ Monocrete, which was like Monier a division of Concrete Industries, advertised a system of slabs containing a row of cylindrical hollow cores.¹⁴¹

A bizarre example reported in 1954 was a motel at Dalby, Queensland, with walls of 'concrete T-beams precast in aluminium moulds from Scotland'. This was said by George Johnson, who held the local rights, to be a system of Indian origin, and it created a nine inch [225 mm] wall with a five inch [125 mm] cavity.¹⁴² Another

¹³³ Brian Ferguson, 'Reinforcement', in Miles Lewis [ed], *Two Hundred Years of Concrete in Australia* (Sydney 1988), p 116; Diane Hutchinson, 'The Post-War Cement Industry' in Lewis, *Two Hundred Years*, p 120. For the Melbourne Grammar boatshed see also *Ramsay's Catalogue* [1954], § 6/5.

¹³⁴ J P Mockridge, 'The Architect and Good Design - their Value in Contemporary Building and Living', *The Valuer*, 1 October 1956, p 12.

¹³⁵ *Ramsay's Catalogue* [1954], § 18/7.

¹³⁶ Information from Graeme Butler, 2001.

¹³⁷ Information from Sylvia Whitmore, 2007.

¹³⁸ Hutchinson, 'The Post-War Cement Industry', p 120.

¹³⁹ *Cross-Section*, no 13 (November 1953), p 2.

¹⁴⁰ *Ramsay's Catalogue* [1954], §§ 6/2, 6/4.

¹⁴¹ *Ramsay's Catalogue* [1954], §. 6/3.

¹⁴² *Cross-Section*, no 18 (1 April 1954), p 1.

oddity was the 'Filigree' hollow block floor system introduced by K-M Steel Products under a German patent, in which reinforcing bars were cast into a concrete truss with a concrete 'foot' or lower chord, while the balance stood out ready to be encased in *in situ* concrete.¹⁴³

i. tilt slabs & panels

Among the many other experiments in concrete house construction in the 1920s and 1930s there were four involving what would now be called tilt-up slabs. One was to be transformed into something quite different, and the other was one destined to evolve into a monster. An inventor by the name of Arnold devised a system of casting on the flat 75 mm concrete walls reinforced with steel bars, seasoning them for several days, then tilting them into position with cranes and welding the junctions and corners. Several of these houses were built in Footscray and Sunshine, and were apparently satisfactory, but still not as cheap as Arnold desired. He now turned to the use of thinner concrete slabs nailed onto a conventional timber framework, with the joints filled afterwards. The system was called Arnolite, and hundreds of houses were said to have been built of it, including a large number at the State Electricity Commission's model town of Yallourn.¹⁴⁴ It was marketed by Brodrick, Basely & Co of Melbourne as sole agents.¹⁴⁵ Paul Roser has identified a house at 44 Queen Street, Altona as having been built in 1928 by William Arnold, who seems likely to be the same man, though Roser believes the wall to consist of two inch [50 mm] leaves with a 20 mm cavity. There is a similar looking house at 25 Queen Street.¹⁴⁶

By 1925 Edward Stone, the greatest concrete innovator in Australia, had developed a system in which hollow wall slabs were cast in steel moulds, either at a factory or, preferably, on site. They had specially designed joints, and included projections for fixing wall and floor plates, as well as holes to take plugs for picture rails, skirtings and other attachments. These slabs were 'rigidly held by longitudinal rods', and apparently created a monolithic whole. We can probably infer that the rods were used in the same way as in Stone's earlier system of construction, in which loops projected from the edges of the joining slabs, and the rods were dropped through both sets, thus uniting the slabs, and were then grouted into place. The slabs were cast with a smooth inner face and a sanded or roughcast outer side, so as to obviate the need for plastering or finishing. The joints were either covered with strips externally, giving a panelled appearance, or pointed up to give flat surface. A flat roof of precast slabs was an option.¹⁴⁷

F Rebell of Perth patented something similar in about 1926. Slabs of up to fifteen by twelve feet [4.5 x 3.6 m], the side of a room, were cast on the flat either at a central yard or on the building site. The reinforcement consisted of round steel bars at one foot [300 mm] centres, and the looped ends of the rods were exposed at the edges and

¹⁴³ *Cross-Section*, no 69 (1 July 1958), p 3.

¹⁴⁴ R V F Eldridge, *Concrete and Cement Work* (Melbourne, no date [1937]), p 27.

¹⁴⁵ Eldridge, *Concrete and Cement Work*, p 61.

¹⁴⁶ Roser, 'Concrete House in Victoria', p 12, where the discovery of 44 Queen St is credited to Suzanne Zahra.

¹⁴⁷ Edward Stone, 'The Claims of Concrete', *Australian Home Beautiful*, 12 December 1925, p 34.

locked together with common bolts. Thirty-three wall, partition and floor slabs, together with fourteen other concrete sections, were required to build a house. The outer walls were three inches [75 mm] and the partitions two inches [50 mm] thick. Cold paraffin wax or bitumen was used to waterproof the exterior walls, which were finished in roughcast.¹⁴⁸ It is difficult to see that this differed materially from Stone's system, Arnold's original one, of the better known one of Fowler.

T W Fowler, a surveyor, began building concrete dairy sheds and other buildings in the 1920s on his farm at Werribee South, Victoria, and a house which is believed to be one of his early experiments survives there.¹⁴⁹ Over time he developed a system of casting the walls in the form of 76 mm slabs complete with the required openings, on horizontal tables next to the place of erection. They were then tilted up onto previously prepared concrete piers.¹⁵⁰ Fowler patented his system in 1928.¹⁵¹ The system was now accepted by some of the more concrete-minded architects and engineers, such as Leslie M Perrott.¹⁵² In about 1937 Perrott designed two houses on Fowler's system which were built at Brighton by the Australian Cement Co, which was supporting Fowler financially.¹⁵³

Meanwhile Fowler's operations continued at Werribee¹⁵⁴ and nearby at Laverton.¹⁵⁵ When the newly established Victorian Housing Commission held a competition in 1939 for the design of houses, the second and fourth placegetters, A C Leith, of Leith & Bartlett, and Frank Heath, both designed their entries on the Fowler system.¹⁵⁶ The architectural panel appointed by the Commission, which included both Leith and Heath, designed an experimental pair of precast concrete houses on the Fowler system, which were built in 1939 at 324-6 Howe Parade, Port Melbourne.¹⁵⁷ Leith's design proved the most economical, and in 1940 the Commission gave Fowler contracts to build twenty-eight houses. After these more were built either by Fowler himself or by others using his plant under licence. In the years 1942-3 the

¹⁴⁸ *Argus*, 25 January 1927, p 8.

¹⁴⁹ On the west side of Duncan's Road, south of the intersection of Robbs Road: information from Peter Mills of Heritage Victoria, 2001.

¹⁵⁰ See, principally, H Bechervaise, 'History of the Concrete House Project' (BArch. history thesis, University of Melbourne 1970); also 'Housing in Victoria', *Architecture*, XXXIV, 2 (April-June 1945), pp 180-5; Kell, op cit, p 42. Also Roser, 'Concrete House in Victoria', p 22, cites 'Concrete Houses and the Fowler System of Construction', in Victoria, Housing Commission, *Sixth Annual Report 1943-44*, pp 23-5

¹⁵¹ Patent no 3982, described in *Building and Construction*, 17 April 1928, and cited by Roser, 'Concrete House in Victoria', p 22.

¹⁵² *Australian Home Builder*, March 1924, p 41.

¹⁵³ *Age*, 7 September 1937, 20 December 1938, and Philip McKay, 'The History of the Cement Industry 1939 to 1977' [mimeographed report for the Cement & Concrete Association] (no place or date), pp 20-21. Also Roser, 'Concrete House in Victoria', cites Royal Victorian Institute of Architects, *Journal*, IX, July-August 1937, pp 120-122.

¹⁵⁴ *Argus*, 9 March 1939, carried an extensive article on houses built by Fowler at both Werribee and Brighton. Peter Mills advises of another surviving house, at the north-east corner of Duncans and Robbs Roads, which he believes to be that built for G Barker on his irrigation block, as reported in the *Age*.

¹⁵⁵ *Age*, 12 October 1939, reports the completion of cheap houses on Fowler's system at Laverton.

¹⁵⁶ Bechervaise, &c, as above. However according to Renate Howe, 'Reform and Social Responsibility', in Renate Howe [ed], *New Houses for Old* (Melbourne 1988), p 38, the first and second placegetters were E C Jackson of the Commonwealth Public Works Department, and Eric Andrew of Sydney.

¹⁵⁷ Heritage Victoria, registration data on 324-6 Howe Parade, Port Melbourne.

Commission experimented with a rival type, 'Millar prefabricated concrete slabs'. This used precast concrete stumps, bearers, studs and wall panels, but conventional timber roof framing. The proprietors undertook not to exceed the unit cost of Fowler construction, and to add a three year maintenance period. An experimental pair of units was built in Coker Street, Newport.¹⁵⁸ However no more is heard of the system, and it probably proved uneconomic.

Fowler died in 1942 and his plant was leased to a firm of builders, who still operated it manually and produced three houses a week, using six fixed tables and employing twenty-eight men. By 1944, however, the plant was lent to the Housing Commission, which began to invest in mobile cranes and tilting tables to raise the slabs to the vertical position. By 1945 the Commission was employing between eighty and a hundred men on concrete house production, and it took a lease on a Commonwealth factory at Holmesglen which had been making armoured vehicles and tank turrets during the war. Here the Fowler system was converted into an industrial production line, turning out components which had to be transported to the building site. In 1944-6, 596 houses, or a quarter of the Commission's total output, were manufactured in this way. By October 1948 the total had reached a thousand, by March 1950, two thousand, and by May 1951, immediately before the financial squeeze, three thousand.

The Commission led the way, but was not alone in the field of precasting. The Commonwealth Aircraft Corporation experimented with a prefabricated villa clad externally in 19 mm of concrete containing a waterproofing compound.¹⁵⁹ In South Australia a standardised precast frame, the 'public building frame' was developed as the basis for schools and other public buildings.¹⁶⁰ There was also, from the 1950s, a rapid expansion in the manufacture of precast cladding panels, often finished with exposed aggregate, such as those made by EPM and referred to above.

In 1946 Concrete Industries (Aust) Ltd formed a subsidiary company, Monocrete Pty Ltd, which produced 100 mm thick hollow precast panels, fitting between grooved precast posts. This system was used first for houses and then for a number of schools in New South Wales in the 1950s.¹⁶¹ By 1948 Monocrete had headquarters at Villawood in Sydney, a branch at Kingston in Canberra, and R P McInery & Co Pty Ltd as managing agents for Western Australia.¹⁶² By 1957 there were factories at all three places, and at Villawood there was also a demonstration area.¹⁶³ However in 1959 it was reported that there had been 270 complaints of dampness from occupants of the 945 Monocrete houses at Canberra, built for the Commonwealth Housing Department. In some cases a black fungus had grown, and six houses had been evacuated.¹⁶⁴ This may well have marked the end of this domestic building system,

¹⁵⁸ Housing Commission of Victoria, *Fifth Annual Report of the Housing Commission of Victoria for the period 1st July, 1942, to 30th June, 1943* (Melbourne 1943), pp 11-12.

¹⁵⁹ F Wentworth & W L Richardson [eds], *Ramsay's Architectural and Engineering Catalogue* (Melbourne 1949), § 11.4.

¹⁶⁰ Hutchinson, 'The Post-War Cement Industry', p 119.

¹⁶¹ Hutchinson, 'The Post-War Cement Industry', p 119.

¹⁶² Associated General Publications Pty Ltd, *Sixty Home Plans* (Sydney 1948 [1946]), p 84. See also p 20.

¹⁶³ George Topham, *Be Your Own Builder* (Sydney 1952), p 87.

¹⁶⁴ *Cross-Section*, no 83 (1 September 1959), p 1.

but by 1957 the parent company, Concrete Industries Ltd, had begun producing 'packaged factory buildings', using centre-pinned precast concrete portal frames, and precast infill wall panels and purlins.¹⁶⁵

The Victorian Housing Commission's buildings now began to grow upwards. But for one partial exception all the houses built so far had been single-storeyed. In 1952 the Commission produced its first two storey structures, using 100 mm walls. In 1954 a four storey block was put up at Jordanville and tested under lateral load, as a result of which it was decided to introduce positive connection between wall and floor slabs. In 1957 building regulation approval was given for three storey units, and an application was lodged for five storey ones. In 1958-9 four storey blocks were built, containing two levels of two storey maisonettes, one above the other, but these were unsatisfactory, and within two years they were phased out in favour of four storey blocks consisting entirely of conventional three bedroom flats. Nonetheless, the Victorian Housing Commission was set on the road to high rise flat construction, a technical triumph and social tragedy which was emulated to a greater or lesser degree by other public housing authorities in Australia.

j. lift slab

Many of the improvements and experiments in concrete construction, like lift slab, were almost entirely confined to large scale or specialised projects. In lift slab construction the columns, usually of steel, were put up first, and were held in place with guys. The slabs were cast on the ground floor, then raised to their final position and fixed to the columns, usually by welding steel plates cast into the slabs.¹⁶⁶ The concept was an American one which had been introduced to Britain in the 1950s, but with limited success for in 1956 experienced engineers still were experiencing difficulty in separating the floors, cast as they were on top of each other.¹⁶⁷ The system was patented by the International Lift Slab Corporation of Texas, but the equipment for it was imported to Australia in 1956 and used by a subsidiary of A B Cair Ltd of Sydney.

It was proposed to use lift slab for the first time at Fuller House, Little Collins Street, Melbourne, a complex designed by Harry Seidler and containing an office block above the Grand Central Carpark.¹⁶⁸ However, this may not have eventuated, for it was reported in 1957 that there had been many announcements of proposed lift slab structures, but the first actually carried out was the three storey Behr-Manning office building at Lidcombe, New South Wales. The Behr-Manning block took six weeks to build, and the walls were poured continuously in forms rising ten inches [250 mm] an hour.¹⁶⁹ The next example was the A G Watson warehouse in Grant Street, South

¹⁶⁵ *Cross-Section*, no 57 (1 July 1957), p 2.

¹⁶⁶ K Hajnal-Kónyi & H Tottenham, 'Concrete', in Eric de Maré [ed], *New Ways of Building* (London 1958 [1948]), p 58.

¹⁶⁷ Marian Bowley, *The British Building Industry: Four Studies in Response and Resistance to Change* (Cambridge 1956), p 121.

¹⁶⁸ *Cross-Section*, no 43 (1 July 1956), p 1. See also no 18 (1 April 1954), p 2; no 34 (1 August 1955), p 2; no 42 (1 April 1956), p 2.

¹⁶⁹ *Cross-Section*, no 56 (1 June 1957), p 3.

Melbourne, where Lift Slab Australia Ltd used twelve jacks to raise a slab of 492 square metres, weighing 280 tonnes.¹⁷⁰

In January 1958 a proposed nine storey block of lift slab flats at Potts Point was announced,¹⁷¹ and at the same time it was announced that the world's tallest lift slab building, of seventeen storeys, would be begun in May. This was the Royal Exchange Assurance office block in O'Connell Street, Sydney, designed by Kenneth McConnell, Smith & Johnston.¹⁷² In 1959 a nine storey block of flats called 'Glenhurst' was being built at Darling Point, Sydney,¹⁷³ and by March, as the floor slabs began to rise, it was reported that this would be the world's tallest lift slab structure until the completion of the Hotel International at King's Cross and the Royal Exchange Assurance building - apparently still proceeding.¹⁷⁴ In May, however, the big day arrived, and with three hundred guests standing on the seventeenth floor of the Royal Exchange building:

the Chairman pressed the button starting the lift motors - repeatedly, to satisfy press photographers - coloured lights flashed, crackers burst; the slab, variously estimated to weigh 150 or 1200 tons, was presumed to have begun to lift. Progress was imperceptible. Men hit lifting spindles with pieces of wood, encouraged hydraulic jacks. Spectators wondered. Light refreshments set in, visitors began to leave, one of the architects was observed being interviewed by Pravda's correspondent. Four hours later, the slab having moved perhaps a foot, a knot of onlookers still gazed in from the street, hungry for levitation¹⁷⁵

This anticlimax may not have killed the idea, but it was a straw in the wind. The vogue for lift slab passed. Prices for a block of flats at Crow's Nest, Sydney, were estimated at £415 per square in lift slab, but £381 in conventional construction, which was of course adopted.¹⁷⁶

k. prestressing

Prestressing had been pioneered by Freyssinet in France, and was then extensively developed in Germany and Belgium. The principle of applying permanent compressive stress to concrete prior to its being loaded had been experimented with at earlier dates, but it was impossible to maintain this stress by using mild steel because of the problems of shrinkage and creep. It was in 1927 that Freyssinet recognised that high tension steel was required,¹⁷⁷ but this exacerbated another problem – that of devising a system of anchorage to which such stress could be transferred from the tensioning equipment without excessive losses. Freyssinet and others devised and patented anchors to meet this requirement.

¹⁷⁰ *Cross-Section*, no 57 (1 July 1957), p 2.

¹⁷¹ *Cross-Section*, no 63 (January 1958), p 3.

¹⁷² *Cross-Section*, no 63 (January 1958), p 3; no 72 (1 October 1958), p 2.

¹⁷³ *Cross-Section*, no 76 (1 February 1959), p 1.

¹⁷⁴ *Cross-Section*, no 77 (1 March 1959), p 2.

¹⁷⁵ *Cross-Section*, no 79 (1 May 1959), p 1.

¹⁷⁶ *Cross-Section*, no 76 (1 February 1959), p 2.

¹⁷⁷ Gustave Magnel, *Prestressed Concrete* (2nd ed, London 1950 [1948]), p v.

The Anglophone world was slow to pick up these developments, but after Dr Karl Mautner (1881-1949) was bought out of Buchenwald and came to Britain he joined Mouchel & Partners in 1938 in forming the Prestressed Concrete Co, of which Alan Harris was chief engineer until he retired for private practice in 1955. After the war Francis Walley went from Britain in December 1946 to investigate German practice, and produced a report in 1947. Gustave Magnel visited the United States in 1946, and in 1948 his book *Prestressed Concrete* was published in Britain. In 1949 the Walnut Lane Bridge, Philadelphia, was constructed on Magnel's system.¹⁷⁸

In Australia Prestressing was first discussed in a Building Station report of 1949,¹⁷⁹ and the Freyssinet system was introduced soon afterwards by John Harris¹⁸⁰ (whether a relation of Alan Harris is unclear). The first use of prestressing in Australia was in the Queensland University building, St Lucia, Brisbane, in 1953, and at this time it was also under consideration for Brisbane bridges.¹⁸¹ In Sydney a proposal for the use of prestressing in the remodelling of Pfahlert's Hotel was turned down by the City Council in 1953,¹⁸² but in Perth prestressed arches were used for a church at Wembley.¹⁸³

In 1954 prestressed concrete floor joists manufactured by EPM Concrete were used in a private house in the Melbourne suburb of North Balwyn,¹⁸⁴ and later in the year two 'semi-spiral' prestressed beams were used to carry a staircase through two floors at the offices of President Consolidated Limited, Alexandria, Sydney.¹⁸⁵ By 1955 EPM Limited had supplied their 'Stresscon' prestressed concrete beams for a building at William Angliss & Co's factory, Footscray. They were in a sort of chunky I-section which could be used like ordinary spaced beams, carrying a precast slab floor; or with hollow blocks resting between them on their flanges, and grouted to create a deep slab; or placed so close as to touch each other, and create a very strong slab with hexagonal voids between the flanges. EPM also advertised prestressed lintels.¹⁸⁶ Concrete Industries were another producer of prestressed beams, in this case under the Monier brand, in various forms and for spans of up to forty feet.¹⁸⁷

In 1957 prestressed strip flooring units supported on a steel frame structure were used in a building at 231 Bourke Street, Melbourne, by the engineer Emery Balint and

¹⁷⁸ Copresponedence of Chris Burgoyne, Mike Bussell, Michael Gould, David Greenfield, Lawrance Hurst, and James Sutherland, July-August 2007, on the Civil Engineering & Heritage Exchange <civil_engineering_heritage_L@knowledgelists.ice.org.uk>. References are made to Francis Walley, 'The Childhood of Prestressing - an Introduction', *Structural Engineer*, LXII(A) (1984), pp 5-9, to a lecture by Walley published in the *Structural Engineer*, LXXIX, 4 (20 February 2001), and to papers by Chris Burgoyne and Luc Taerwe at the American Concrete Institute symposium 'Historic Innovations in Prestressed Concrete', 2005.

¹⁷⁹ D V Isaacs & J W Drysdale, *Building Technique and Research* (Sydney 1949), pp 58-62.

¹⁸⁰ Brian Ferguson, 'Reinforcement', in Miles Lewis [ed], *Two Hundred Years of Concrete in Australia* (Sydney 1988), p 116; Diane Hutchinson, 'The Post-War Cement Industry' in Lewis, *Two Hundred Years*, p 126.

¹⁸¹ *Cross-Section*, no 5 (1 March 1953), p 1.

¹⁸² *Cross-Section*, no 11 (1 September 1953), p 1.

¹⁸³ *Cross-Section*, no 12 (1 October 1953), p 1; no 19 (1 May 1954), p 2; no 24 (1 October 1954), p 3..

¹⁸⁴ *Cross-Section*, no 18 (1 April 1954), p 1.

¹⁸⁵ *Cross-Section*, no 25 (1 November 1954), p 3.

¹⁸⁶ *Ramsay's Catalogue* [1954], § 6/5.

¹⁸⁷ *Ramsay's Catalogue* [1954], § 6/1.

architect Ernest Fooks,¹⁸⁸ and in the same year as many as six hundred prestressed piles, up to nineteen metres long, were used in the British Nylon Spinners plant at Bayswater, outside Melbourne.¹⁸⁹ By 1958 Stresscrete Constructions Pty Ltd had opened a new plant at Penrith, 65 kilometres from Sydney, and was turning out a variety of products. The prestressing bed was seventy-five metres long and six metres wide, with a stressing capacity of five hundred tonnes.¹⁹⁰ Soon afterwards in the Melbourne suburb of Heidelberg a 6.5 million gallon [30 megalitre] water tank, prestressed on the Freyssinet system, was built by D A Constructions,¹⁹¹ and in 1959 an 800 metre prestressed road bridge was opened between Forster and Tuncurry, New South Wales.¹⁹²

¹⁸⁸ *Cross-Section*, no 53 (1 March 1957), p 3.

¹⁸⁹ *Cross-Section*, no 58 (August 1957), p 1.

¹⁹⁰ *Cross-Section*, no 65 (1 March 1958), p 3.

¹⁹¹ *Cross-Section*, no 74 (1 December 1958), p 1.

¹⁹² *Cross-Section*, no 83 (1 September 1959), p 3.