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Positions and Polarities Beyond Crisis

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WW2 and Its Aftermath: Impact on the Architectural Palette

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Keywords

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Abstract

How were construction materials and products used in Australia, and especially South Australia, during the Second World War through to around 1965? Broadly, the emphasis was on military applications during the war and on consolidation and normalization, rather than innovation and development, in the post-war decade. The architectural palette was severely constrained, though early Modernist architects rose to the challenge. Materials innovation and development in Australia did not fully restart until after 1955. The evidence for these assertions draws from a consideration of a broad range of materials – renewables, earths, metals and synthetics.

Introduction

> It is possible that, owing to war restrictions, some of the proprietary materials mentioned in the editorial pages of Specification may for a time be unobtainable.[1]

In Australia as elsewhere during the war, production and use of materials was transferred urgently from civil to military purposes. For example, Australia built 212 timber-framed Mosquito fast bombers at Bankstown[2] and made its own aircraft for the first time, such as the Wirraway training aircraft.[3] The Civilian Construction Corps built military facilities around Australia, including the US Air Force base at Mount Louisa, Queensland, primarily to support the war in the Pacific.[4] Converting the construction sector from civil to military purpose was challenging but was done very quickly.

How was the reverse managed after the war? Page wrote that 'The decade of 1945–55 was the seminal period for the great advances in building materials and construction methods which were to revolutionize the industry'.[5] But is this correct? An alternative view is that full recovery from the war took over a decade:

> This postwar decade had that precise meaning [that the unresolved business of the war itself – with respect to economic damage, social disruption, political score settling, and so on – was still the dominant feature] also in South Australia.[6]

After the war both Britain and Australia faced housing shortages, and therefore construction materials shortages, as the military was demobilized. For Britain the housing shortages were exacerbated by bomb damage in major cities.[7] Though the British government encouraged citizens to stay and help with the rebuilding,[8] a part of the solution was a reduction in demand through emigration, to Canada, Australia and elsewhere.[9] In Australia the post-war immigration drive was a major cause of materials shortages. From 1947 to 1965, two million immigrants arrived in Australia.[10] The drive was geared to the development of urban industry rather than the rural sector.[11] This policy also affected the return of almost 600,000 demobilized men and women, from 1942 to 1947.[12] A post-War boost in the fertility rate, from 2.54 in 1945 to a peak of 3.4 in 1960, added to demand.[13]

Australia addressed its materials shortages through State-based legislation controlling the use of construction materials, connected to house prices. In South Australia these restrictions ran from the start of 1946 to the end of 1953 and were enacted specifically because 'by reason of conditions brought about by the war in which His Majesty has been engaged, the supply of certain essential building materials is insufficient to meet the demand therefor'.[14] The legislation comprised the Building Materials Act, 1945; the Building Materials Act, 1949; and the Building Operations Act, 1952 (Table 1). The 1945 Act applied to houses with a construction cost of more than £1000, any other building or structure with a construction cost over £150, repairs worth more than £100 to any type of building, and work worth more than £200 involved in splitting houses into multiple occupancies. Similar legislation was enacted in other States.[15]

1. F.R.S. Yorke, ed., *Specification* (Cheam: The Architectural Press, 1941), 3.

2. RAAF Museum, 'History of the de Havilland Mosquito' (Point Cook: RAAF Museum, Point Cook, 2010), https://www.airforce.gov.au/sites/default/files/minisite/static/7522/RAAFmuseum/exhibitions/restoration/dh_98.htm.

3. RAAF Museum, 'A20 CAC Wirraway' (Point Cook: RAAF Museum, Point Cook, 2010), www.airforce.gov.au/sites/default/files/minisite/static/7522/RAAFmuseum/research/aircraft/series2/A20.htm.

4. Department of Veterans' Affairs, 'Civilian Construction Corps paved the way for the forces', *DVA Anzac Portal* (3 June 2019), https://anzacportal.dva.gov.au/stories-service/australians-war-stories/civilian-construction-corps-paved-way-forces.

5. M. Page, *Sculptors in space* (Canberra: RAIA, 1986), 215.

6. S. Marsden, *Twentieth century heritage survey: Stage 1: Post Second World War* (1946-1959): Overview history (Adelaide: Department for Environment and Heritage, 2003-4), 9.

7. M. Kelly, 'Housing after the Second World War', Bristol Ideas (2019), www.bristolideas.co.uk/projects/homes-for-heroes-100/housing-after-the-second-world-war/.

8. National Museum of Australia, 'Defining moments: Postwar immigration drive', NMA (5 July 2021), www.nma.gov.au/defining-moments/resources/postwar-immigration-drive

9. Migration Museum, 'The last great exodus from Britain?', MM (11 January 2016), www.migrationmuseum.org/the-last-great-exodus-of-british-migrants/.

10. National Museum of Australia, 'Postwar immigration drive'.

11. Unlike after WW1. This idea was advocated in W.D. Forsyth, The myth of open spaces: Australian, British, and world trends of population and migration (Melbourne: Melbourne University Press, 1942).

12. K. James, 'Soldiers to citizens', Australian War Memorial (30 March 2021), www.awm.gov.au/wartime/45/article.

13. A. O'Neill, 'Total fertility rate of Australia 1800-2020', Statista (2 March 2021), www.statista.com/statistics/1033428/fertility-rate-australia-1800-2020/.

14. SA Government, *Building Materials Act,* 1945 (Adelaide: SA Government, 1945).

15. NSW Government, *Building Operations and Building Materials Control Act*, 1945 (Sydney: NSW Government, 1945); Queensland Government, *The Building Operations and Timber and Building Materials Control Act*, 1945 (Brisbane: Queensland Government, 1945) – also 1948 and 1951, ceasing 1952; WA Government, Building Operations and Building Materials Control Act, 1945 (Perth: WA Government, 1945).

Table 1: Summary of SA construction materials restrictions, 1946-53

Material/product	Building Materials Act, 1945	Building Materials Act, 1949	Building Operations Act, 1952
Timber	Of a kind usually used for the purpose of the construction of or alteration to buildings	-	-
Flooring boards	-	All	Pinus radiata
Building bricks	Other than refractory bricks or bricks of cement concrete	And bricks or blocks of cement concrete, and breeze blocks	Burnt
Roofing tiles	All	-	-
Cement & cement products	-	Certain uses pro-scribed, e.g., roads, fences	-
Asbestos cement sheets	Corrugated	Corrugated & plain	-
Black and cast-iron pipes	Water and gas		-
Galvanized pipes	Water and gas		Manufactured within the Commonwealth, internal diameter between one-half inch and three inches
Galvanized iron sheet	Corrugated and plain		Manufactured within the Commonwealth, No. 24 & No. 26 gauge
Steel reinforcing rods	-	½ in. or ⅜ in. gauge	-

16. Marsden, *Twentieth century heritage survey*, 42.

Controls on non-residential building were lifted in 1953. New houses, though, remained limited in area – 111 m2 for a timber house and 116 for a brick house – with additions restricted to under £300. This led to the 'austerity house' and other innovations such as staged construction, open-plan layouts, lower ceilings (2.745 m) and no verandahs. These restrictions too had gone by the late 1950s.[16]

17. Marsden, *Twentieth century heritage survey*, 39.

To cover the shortfall, many materials were imported rather than locally made, and black markets developed in cement, but mass production facilitated the use of aluminium, asbestos cement, plate glass, plasterboard, strawboard, and hardboard, especially in Modernist architecture.[17]

Before the War

18. Strawboard is a panel product made using wheat stubble straw. M. Lewis, '5.11 Building boards: Solomit', in *Australian building: A cultural investigation* (2015), www.mileslewis.net/australian-building/.

Several developments and innovations in construction materials happened just before the outbreak of the war, in Australia and overseas. In South Australia, for example, Solomit built its first strawboard factory at Freeling in 1937, and its second at Murtoa, Victoria in 1938.[18] Some

materials had seen no change. Extruded clay bricks had been made in SA since 1853, but dry pressed bricks dominated from the late 19th century through to at least the 1960s, and Hoffman kilns 'dominated the brickmaking industry in South Australia from the First World War to the 1970s'.[19]

19. P. Bell, *Early bricks and brickwork in South Australia* (Adelaide: Department of Environment and Natural Resources, 1998), 21.

Overseas, many plastics had been invented and developed before the war. Plasticized PVC, PVC-P, was invented in 1926 at BF Goodrich in the USA. The first rigid PVC pipes were produced in Germany in 1935 using techniques devised for celluloid. Polychloroprene, 'Neoprene', was commercialized in 1933 by DuPont in the USA. Styrene-butadiene rubber (SBR) was first produced in quantity by IG Farben in Germany in 1935. Polymethyl methacrylate (PMMA), 'Plexiglas', was invented in Germany by Röhm & Hass in 1932. Polyethylene (PE) was invented in England in 1933. Polytetrafluoroethylene (PTFE), 'Teflon', was accidentally invented at DuPont in 1938. Polyamide (PA), 'Nylon', was released by DuPont for hosiery in 1939.

WW2 (1939-1945)

During the war timber supply was problematic everywhere. British need for local timber led Australia to send two 200-man military Forestry Companies to Britain in 1940, and a 150-man unit in 1941. They returned in 1943.[20] Their absence will have affected timber availability in much of Australia. In Queensland, northern rainforest timbers were used locally for defence works, rather than being shipped to the southern States, with the Cairns sawmills operating fulltime on defence from 1942.[21]

20. I. Bevege and G. McKenzie Smith, 'Forestry Units in World War II', *Australian Forest History Society Newsletter* 66 (September 2015), 6-7.

21. Queensland WWII Historic Places, 'Industry: Forestry industries', *Queensland Government* (29 July 2014), www.ww2places.qld.gov.au/homefront/industry.

Plywood is one of the materials that befitted technologically from the war. Its use for barracks, boats, gliders and so on, tripled the number of mills in the USA.[22] A urea-formaldehyde adhesive for plywood, Aerolite, had been invented in Britain in 1935. In Australia the war led to better marine plywood (new adhesives), very thin plywood (as thin as 0.32 mm) from NSW coachwood for use on the monocoque Mosquito bomber (freeing up metal workers and aluminium), and the introduction of plywood made from radiata pine in SA. The CSIRO's Division of Forest Products conducted research used in some of these innovations.[23] In 1944 Australia had 25 plywood mills, 11 of them in Queensland (processing kauri logs for military uses) and just two in SA, which peeled mainly radiata pine but also small amounts of Tasmanian mountain ash.

23. Australian Academy of Technological Sciences and Engineering, 'Technology in Australia 1788-1988', AATSE (1988), 240, https://www.austehc.unimelb.edu.au/tia/240.html.

Concrete development and innovation in SA paused during the war, though in Europe bomb-resistant concrete construction was urgently developed.[24] This was used for massive fortification systems such as Germany's Atlantic Wall, which used 36 million tonnes of concrete and comprised 15,000 bunkers traversing 4,800 km.[25]

24. For British examples, see Yorke, *Specification*; 'Air-raid precautions', 549ff. One example was high strength reinforced concrete roof slabs for ARP shelters, by Frazzi (Yorke, Specification, 100). See also Historic England, *Military structures: Listing selection guides* (London: Historic England, 2017). Concrete was used in Darwin for the Quarantine anti-aircraft battery, observation posts at Dripstone Cliffs, and for undersea defenses in Darwin Harbour: 'WWII Quarantine anti-aircraft battery site', Northern Territory (undated), https://northernterritory.com/darwin-and-surrounds/see-and-do/wwii-quarantine-anti-aircraft-battery-site; P. Forster, 'Fixed Naval defences in Darwin Harbour 1939-1945', Navy (undated), www.navy.gov.au/history/feature-histories/fixed-naval-defences-darwin-harbour-1939-1945.

25. J. Peterson, 'Nazi megaweapons – a concrete tale', *War History Buff* (20 March 2019) https://warhistorybuff.com/2019/03/20/nazi-megaweapons-a-concrete-tale/

Metals were prioritized for the war effort, though the industry (here represented by British Aluminium) was ever hopeful:

> Whilst aluminium serves first the Empire's first task [i.e. the War], the above-mentioned and other B.A. Co. publications are available freely to architects and designers, in preparation for post-war uses of the metal.[26]

26. *Yorke*, Specification, 334.

Likewise, the Zinc Development Association (UK) suggested a promising post-war future for the material:

> As an essential war material, zinc is now restricted almost exclusively to Government requirements; but in meeting these urgent needs, zinc is adding to its utility for building purposes in general. The widespread use of zinc is an indication of the important part which the metal will take in the future work of reconstruction.[27]

27. *Yorke*, Specification, 278.

Supplies of natural rubber stopped with the Japanese occupation of Malaya in 1941, so industry looked for alternatives for both civil and military use. To a large extent, plastics were adopted as substitutes. Rubber used for insulating electrical cables was replaced by PVC-P, for cabling on military vessels where its inherent fire-resistance (thanks to the chlorine component) was beneficial.[28] Other rubber substitutes included Neoprene and SBR.

28. American Chemistry Council, 'Chlorine compound of the month: Polyvinyl chloride (PVC)', *ACC* (February 2004), https://chlorine.americanchemistry.com/Science-Center/Chlorine-Compound-of-the-Month-Library/Polyvinyl-Chloride-PVC-Its-Hard-to-Imagine-Life-Without-It/.

Other plastics had wartime uses. PMMA was used to replace glass in aircraft windows. PE was used to insulate radar cabling. PTFE was used to contain the volatile gases needed to make the atomic bomb. PA was rationed during the war for parachutes and ropes. During the war plastics production, based on petrol feedstock, nearly quadrupled in the USA.[29]

29. K. Shah, 'A brief history of plastic', *History of Yesterday* (19 September 2020), https://historyofyesterday.com/a-brief-history-of-plastic-2336f7bbdb96; S. Freinkel, 'A brief history of plastic's conquest of the world', *Scientific American* (29 May 2011), www.scientificamerican.com/article/a-brief-history-of-plastic-world-conquest/.

Post-war Decade (1945-1955)

Timber supply took some time to get back to normal after the war. Timber was a controlled material in the SA Acts (Table 1), in Schedule Two of the NSW Act, in the schedule to the WA Act, and in its own section ('Timber control') in the Queensland Act. And so, for example, the South Australian Housing Trust (SAHT) erected more than 1000 imported timber houses at Gilles Plains over 1951-2, and over 3800 imported timber houses at Clearview and elsewhere over 1950-4.[30] The main local innovations were in timber products.Use of hardboard and softboard was not restricted after the war. CSR added a hardboard line to its Sydney softboard plant in 1947 using Swedish technology. The CSR plant and the Masonite Corporation hardboard plant in NSW eventually shifted to using radiata pine as feedstock, rather than eucalyptus and bagasse. A hardboard plant was opened at Burnie in Tasmania in 1952.

30. Marsden, *Twentieth century heritage survey,* 38, 43.

The use of plywood and similar products was encouraged after the war due to the need to use timber economically. For these products 'the rarer and more valuable timbers especially are made to go as far as possible by conversion into thin veneers.'[31]

31. W.B. McKay, *Building construction volume three* (London: Longmans, 1963), vi (Preface to the first edition).

In 1946-7 the Modernist architect Robin Boyd used Solomit strawboard panels experimentally to roof his house at Camberwell, Victoria, surfacing it with bituminous felt and gravel – this caught on.[32] Over the 1950s Solomit production grew to thousands of strawboard sheets for acoustic ceilings, insulation, and some houses such as its display house in Brighton, SA in 1952.[33] In 1954 another strawboard product, Stramit, began production at Bendigo.[34]

32. Lewis, 'Building boards: Solomit'.

33. Marsden, *Twentieth century heritage survey*, 39.

34. Stramit had been invented in Sweden in the 1930s. With a water-resistant paper face, it was designed for roofing, covered in asphalt after the joints had been taped and filled: J.J. McKay, *Building construction volume four* (London: Longmans, 1961), 178-9.

Bricks remained in short supply – various kinds were restricted by the SA Acts (Table 1), and in the NSW (in their own Division), Queensland and WA Acts.[35] The last Hoffman kiln in SA was built in 1951, at Glen Osmond.[36] A new type of kiln, the tunnel kiln, was first built in Victoria in the 1950s by Brick Industries, having been advocated by the Building Research Division of the CSIRO in 1950.[37]

35. Bricks were controlled elsewhere, including Northern Ireland: NI Ministry of Commerce, *Bricks (Control) (Northern Ireland) Order, 1943* (Belfast: NI Ministry of Commerce, 1943).

36. Bell, *Early bricks and brickwork*, 22.

37. I. Stuart, 'The history and archaeology of the Hoffman Brick and Tile Company, Melbourne, Australia', *Industrial Archaeology Review* 17/2 (1995), 129-144.

The use of concrete in architecture seems to have continued through the war and the post-war decade, but supply was short. It was included in one SA Act and the WA Act, as 'cement and cement products.' After the war a black market in imported cement developed which led the SA government to support the construction of a new kiln at Birkenhead, by the Adelaide Cement Company, in 1953.[38] The SA Portland Cement Company relocated its Marino kiln to Angaston in 1952.

38. Marsden, *Twentieth century heritage survey*, 39.

Window glass was controlled in the NSW Act. The 1950s saw some innovation. Rolled pattern glass (such as Kosciusko and Coogee) was produced through the 1950s to the 1970s. In the USA, Libbey-Owens-Ford had developed double-glazing, Thermopane, also used in Australia. Crownlite, a ceramic-coated heat-absorbing annealed plate glass made by Australian Consolidated Industries (ACI), had failed in two curtain wall projects in the mid-1950s: at the GMH Factory, Dandenong, and at a 12-storey office block in Adelaide. These thermal stress fracture failures led to a report recommending the use of toughened glass for spandrels. Plasterboard – set gypsum sandwiched between two layers of heavy paper – replaced wet plaster for flat work and preformed fibrous plaster for plain sheets. After the war fibrous plaster sheets were cast in multiple small-scale backyard factories to meet demand.[39] Industry thought the demand could be better met by dry-wall construction, and so plasterboard was first made in Australia in 1947, by CSR Gyprock at Concord, NSW.

39. M. Goodchild, 'Plastering over the cracks', *Architecture & Design* (16 October 2008), www.architectureanddesign.com.au/news/industry-news/plastering-over-the-cracks#.

Asbestos cement (aka 'fibro') was a conventional and everyday material.[40] It experienced a post-war boom:

> Its greatest use came with the explosion of house construction in the postwar years from 1945 to the close of the 1960s. By the mid-1960s, it featured in almost 20% of all housing stock.[41]

40. Though in the UK it was being used during WW2 for 'a neat and efficient wall constructed for protection against bomb blast' by Turners Asbestos Cement (Yorke, *Specification*, 212).

41. Australian Asbestos Network, *Asbestos history* (Perth: Murdoch University, 2019).

Though the date of 1945 in this quote could be challenged – the material was included in the various control Acts – in NSW alone, 70,000 houses were built using asbestos cement from 1945 to 1954. The bulk of the chrysotile used by James Hardie for its Australian asbestos cement products was imported from Canada.

The UK and USA had substantial aluminium industries that had been set up for aircraft manufacture but, at the end of the war, were 'in search of a market'. There was also a great deal of scrap aluminium from unwanted aircraft that needed a purpose.[42] Neither situation applied in Australia. Aluminium used in Australia was imported to the end of the post-war decade, and so remained expensive.[43] Perhaps because it was simply not being imported, it was not scheduled in the various building materials control Acts. But in the USA the aluminium surplus seeded innovation, most notably the development of the glazed curtain wall. Early examples were the Equitable Savings & Loan Building, Portland in

42. J. Ashby, 'The aluminium legacy: The history of the metal and its role in architecture', *Construction History* 15, (1999), 85. Production ceased in 1949 due to the expense.

43. It took some time for Australia to produce aluminium locally from scratch, despite having the world's second largest bauxite reserves (as of 2020).

1948, by Pietro Belluschi, and the Alcoa Building, Pittsburgh in 1953, by Harrison & Abramovitz.[44]

44. Ashby, 'The aluminium legacy', 86.

Unlike aluminium, iron and steel were widely controlled. Various products were scheduled in the SA Acts (Table 1). Structural and reinforcing steel was controlled in the NSW Act along with various items made from iron and steel including wire, nails, water and gas pipes, ferrous castings, bolts and nuts, and sheet steel. The WA Act listed wire and wire products (e.g. nails), water and gas pipes, and ferrous castings. Nevertheless, steel sections were developed for use in housing. A system called Econosteel was developed – uncoated steel sections dipped in bituminous paint.[45] It was used for over 300 houses in the ACT after 1945 but was six times more expensive than timber. The first standard for cold-rolled steel sections was published in 1946 by the American Iron and Steel Institute.[46]

45. Presumably because zinc for galvanizing was hard to come by at this time.

46. D. Allen, 'History of cold formed steel', *Structure* (November 2006), 28-32.

Galvanized iron remained in short supply in the post-war decade. Galvanized iron sheets (corrugated and plain) and pipes were listed in the material control Acts in SA, sheets in NSW, and 'galvanized iron' generally in WA.

The wartime increases in plastics production, as for aluminium, led to oversupply, with manufacturers such as DuPont looking for civil uses for these materials. New plastics were also developed, such as polypropylene (PP) and high-density polyethylene (HDPE), developed in the USA by Phillips Petroleum in 1951 and 1954 respectively.[47] In the 1950s rigid PVC (PVC-U) was developed in grades that were readily extruded or molded, thanks to improvements in polymer production and stabilization. The potential uses of PVC in construction expanded accordingly and it is now the most widely used plastic in construction.

47. American Chemical Society, *Discovery of polypropylene and the development of a new high-density polyethylene* (Washington: ACS, 1999).

The history of fully Australian-made PVC spans just over 40 years from its post-war start to its finish in 1996. In 1954, the ICI electrolytic mercury cell chloralkali plant at Botany, NSW (built in 1941), had surplus chlorine capacity, which was used to make vinyl chloride monomer (VCM). This was polymerized to create just 5000 tonnes a year of PVC. The process initially used costly acetylene gas, made from Tasmanian calcium carbide. The acetylene was converted to EDC (ethylene dichloride) which was then converted to the VCM.[48] The production of PVC in Australia from Australian feedstocks (salt and calcium carbide) meant that Australia could now make its own PVC pipes and vinyl flooring (invented in Sweden in 1947).[49]

48. Chemlink Australasia, 'ICI Australia – Development in Australia', *Chemlink* (1997), www.chemlink.com.au/orica_hist.htm.

49. British Plastics Federation, 'The story of polyvinyl chloride (PVC)', *BPF* (2014), www.bpf.co.uk/plastipedia/plastics_history/Default.aspx.

1955 and Beyond

After 1955, development in hardboard and softboard continued with new plants at Ipswich in Queensland in 1958, and Bacchus Marsh, Victoria, in 1961.[50] The first production of particleboard in Australia was in 1957 at Mount Gambier, by Coreboard. A second particleboard plant was built in 1960, at Oberon, NSW.[51] The product is now ubiquitous.

50. AATSE, 'Technology in Australia', 242, https://www.austehc.unimelb.edu.au/tia/242.html.

51. AATSE, 'Technology in Australia', 244, https://www.austehc.unimelb.edu.au/tia/244.html.

The number of plywood mills increased to 55 by 1970, as the industry benefited from the development of synthetic (formaldehyde) glues

between 1955 and 1966. An important and innovative example of plywood in this period is the use of Australian white birch from Wauchope, NSW, in the Sydney Opera House Concert Hall ceiling and chair shells, built 1967-73, and designed by Jørn Utzon and Peter Hall.[52]

Over the 1960s Solomit production continued to grow.[53] Used as a ceiling panel, it became a well-known part of the palette of Dickson and Platten Architects, in Adelaide.[54]

In the 1960s Hallett Brick Industries built the first (American-designed) tunnel kiln in Adelaide, at Golden Grove. All Hoffman kilns ceased production by the early 1980s. For shaping bricks, in 1969 Watson Sharp called dry pressing 'the most modern method' – as already noted, brickmaking was conservative.[55]

For concrete, innovation happened after the post-war decade. For example, concrete arch frames, new to SA, were used by the SAHT in 1958 for the Pioneers Memorial Hall at Seacombe Gardens.[56] In the 1960s, SA Portland Cement introduced sulfate-resisting cement (SR), masonry cement, and Brightonlite, an off-white cement (HE).[57] Brighton Tan cement was used in several Brutalist buildings in Adelaide built in the 1970s for the State government.[58]

ICI House, Melbourne, built in 1958 and designed by Bates Smart & McCutcheon, was Australia's first skyscraper, at 84 m. Its curtain wall was glazed from the outside using plate glass, with the spandrels made from grey ceramic toughened plate glass. But these spandrels failed – nickel-sulfide intrusions were identified as the cause. All 700 panes of blue Belgian Pan-O-Glass were removed.[59]

Pilkington perfected the float glass process in 1959 and the first production plant was opened in the USA in 1962, by Pittsburgh Plate Glass.[60] Despite local production capabilities, most building glass was imported, from Belgium (Glaverbel), the UK (Pilkington) and the USA (Pittsburgh Plate Glass and Libbey-Owens-Ford). For example, Pittsburgh supplied the glass for the Shell Corner Building by SOM (1960) and BHP House (1969-72), in Melbourne. Watson Sharp made no mention of float glass.[61]

Plasterboard did not become ubiquitous in Australian construction until the 1960s. Again, Watson Sharp did not mention it, saying that fibrous plaster was 'almost universally used in preference to plaster on laths.'[62] In 1962 Gyprock developed vinyl cements for crack-resistant jointing of the sheets (this is American practice – in the UK the entire sheet is skim coated, using square-edged blueboard). Plasterboard cement was introduced in 1964.

The first building in Australia with an aluminium-framed curtain wall was the MLC Building, North Sydney in 1955-7, by Bates Smart & McCutcheon. The sister MLC Building in Adelaide was also built 1955-57. The curtain walls for ICI House, Melbourne (1958), were also framed using extruded aluminium.[63]

On the Gold Coast about 50 steel framed homes were built by an American company in the 1960s, using galvanized cold rolled steel

52. B. Toogood, *Sydney Opera House 02 Architectural resource package* (Melbourne: Forest & Wood Products Australia, n.d.).

53. Solomit, 'Acoustic strawboard ceilings', *Solomit* (n.d.), https://solomit.com.au/acoustic-strawboard-ceilings/.

54. ArchitectureAU, 'Dickson and Platten, architects: 1950-2000', *ArchitectureAU* (6 October 2017), https://architectureau.com/calendar/exhibitions/dickson-and-platten-architects-19502000/.

55. W. Watson Sharp, *Australian methods of building construction* (Sydney: Angus and Robertson, 1969), 41.

56. Marsden, *Twentieth century heritage survey*, 39.

57. Adelaide Brighton Cement, 'About us: Company history' (Adelaide: Adelaide Brighton Cement, 2013).

58. K. O'Sullivan, *Concrete expressions: Brutalism and the Government buildings precinct, Adelaide* (Adelaide: University of South Australia, 2013).

59. G. Marfella, 'From heat absorption to speculation: The troubled evolution of international all-glass architecture in Melbourne (1955-1985)', in *GOLD: the 33rd Annual Conference of the Society of Architectural Historians, Australia and New Zealand*, eds. A-M. Brennan and P. Goad (July 2016), 404-417.

60. D. Barrett, *Australian Window Glass/ Pilkington ACI/Viridian* (archive) (Sydney: Museum of Arts & Sciences, 2009).

61. Watson Sharp, *Building construction*, 377-78.

62. Watson Sharp, *Building construction,* 367. The 1969 revision was clearly not thorough.

63. L. Cheng, 'Australia's first skyscraper turns 60', *ArchitectureAU* (11 December 2018), https://architectureau.com/articles/australias-first-skyscraper-turns-60/.

frames finished with stucco. Lysaght supported the construction of a galvanized steel-framed house by the National Capital Development Commission in Belconnen, ACT.[64]

Metals production in Australia saw many developments after the post-war decade. For aluminium, the Bell Bay smelter in Tasmania began production in 1955 at just 1200 tpa, as a joint Australian/Tasmanian government operation, using imported alumina. Planning for this project had begun in 1944. Commercial mining of bauxite – along with the production of alumina – did not begin in Australia until 1961, at Weipa in Queensland.

For steel in SA, BHP opened a Basic Oxygen System (BOS) furnace, a second blast furnace and a rolling mill at Whyalla, in 1965. For zinc, Lysaght commissioned its first continuous galvanizing line at Port Kembla (NSW) in 1961. Through the 1960s, Lysaght introduced terne (alloy of lead and tin) coated steel (Terne Sheet), vinyl coated steel (Marviplate) and, in 1966, pre-painted steel – better known as Colorbond.

For PVC manufacture in Australia, the acetylene process was replaced at Botany in 1963 by one using the cheaper ethylene. The ethylene was produced by a new (1960) naphtha cracker on site and then converted to EDC. This plant produced around 60 000 tonnes of PVC a year.[65] But PVC was a material still looking for applications, often the case for new plastics. Vinyl wall coverings were only developed in 1966.[66] Watson Sharp (1969) mentioned polyethylene pipes, but not PVC.[67] Overseas saw the development of second-generation pre-war elastomeric sealants in the 1960s, including one-part polysulfide sealants, one-part silicone sealants, and two- and three-part urethane sealants.[68]

Conclusion

WW2 and its aftermath substantially interfered with the innovation and use of construction materials in South Australia and beyond. Materials innovations during the war included plywood in Australia, and new plastics such as PVC-P, developed overseas. Materials innovations in the post-war decade in Australia included fiberboards, brick firing, glass, plasterboard, and PVC production. But the situation in Australia was marked by widespread legislated materials controls. Overseas saw the development of aluminium curtain walls, rigid PVC, and several new plastics.

After 1955 in Australia the controls had gone. Materials innovation increased and included particleboard, formaldehyde glues for plywood, curved plywood, concrete arch frames, new types of cement, float glass, plasterboard cements, aluminium curtain walls, galvanized cold rolled steel, local production of aluminium, in-line galvanizing and other new steel finishes, and cheaper PVC production.

For the most part, innovations and developments in Australia happened after the post-war decade and controls happened during it. The architectural palette was reduced by the war and its aftermath for 15 years or so. Page's claim of 'great advances' in the post-war decade was overstated.

64. National Association of Steel Framed Housing, *History of steel framing* (Hartwell: NASH, n.d.).

65. Chemlink, 'ICI Australia'.

66. British Plastics Federation, 'The story of polyvinyl chloride'.

67. Watson Sharp, *Building construction*, 228.

68. M. Scheffler and J. Connolly, 'History of building joint sealants', in *Science and technology of building seals*, sealants, glazing, and waterproofing, Volume 5, ed. M. Lacasse (West Conshohocken PA: ASTM, 1996), 85-94.