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Some Assembly Required: Component and Ensemble in Prefabricated Australian Domestic Construction

Despite a resurgence in prefabricated residential construction, building culture in Australia remains largely an industry arranged around an assembly of construction systems segregated by specialized trade-based knowledge. Off-site prefabricated projects such as Fender Katsalidis' Maxx Apartments and Donovan Hill's work in modular transportable housing appear to be solutions that respond to Australia's geographical position as one of the most remote, though urbanised and centralized countries in the world. However, these examples are exceptions rather than the dominant contemporary fabrication practice. This paper will examine historical examples of prefabrication in Australian domestic construction. This analysis reveals a construction culture based on the component rather than ensemble. Construction product catalogues such as Goodlet and Smith Ltd. trace a continuous history of prefabrication by discrete parts, which closely resembles how architects specify building components today. This suggests a building culture historically resistant to change, regardless of developments in construction technology. This paper frames prefabrication of the ensemble as an historical aberration, when compared with building as a configuration of standardized components.

Introduction

Building culture in Australia is experiencing a renewed interest in the potential of prefabricated construction. Fabricators such as Unitised Building, Hutchison Builders and John Holland are investing significant amounts of research and capital into the realisation of prefabricated building systems. Recently the architectural practices of Architectus, BVN Donovan Hill and Fender Katsalidis among others have completed projects utilizing digital and industrial prefabrication techniques. In the last four years bodies such as prefabAUS, established in 2012 and PrefabNZ, established in 2010, have been formed with a view to promoting the benefits of prefabricated construction. Notably PrefabNZ has set the target of doubling the uptake of prefabricated building to forty percent by 2020.[1] Such objectives, and their framing in contemporary architectural culture, set up an interesting distinction in the way in which prefabrication is considered.

Prefabrication of individual elements such as doors windows and joinery is already a ubiquitous practice. Implied in the renewed interest in off-site assembly is the potential of an approach where efficiencies and quality control in prefabricated construction are brought to bear at a much larger scale. This methodology is not just a present-day ambition, as Burnham Kelly noted in his detailed 1951 study on prefabrication, "there may be said to be various degrees of prefabrication, of which pre-cutting might be one, the fabrication of panels another, the construction of volume enclosing sections a third, and the manufacture of a complete mobile dwelling unit probably the ultimate."[2]

Similar themes are expanded upon in Pamela Bell's typological analysis of prefabrication in New Zealand. Bell defines off site assembly as taking place in five typological modes: component, stick build or sub-assemblies; panellised, non-volumetric construction; module, three-dimensional structural units; hybrid, semi-volumetric or hybrid module-plus-panel; finally, complete Buildings, volumetric prefabrication of entire transportable buildings.[3] This paper will look to simplify this taxonomy of prefabrication by considering off-site assembly on a spectrum between singular elements and the complete transportable dwelling, more specifically from the component to the ensemble.

Considered as a range of solutions from component through to the whole, significant research and investment is being directed toward the ensemble end of the prefabricated construction spectrum. Recent technological improvements in digital and automated fabrication undoubtedly play a role, however the desire for a fully prefabricated built ensemble has a long history. As far back as 1624 housing constructed using prefabricated timber panels were shipped from England to a fishing fleet based in Cape Ann.[4] Given the desire to realize a fully prefabricated built outcome is not

1 "About Us/PrefabNZ." PrefabNZ. 20 January 2014. http://www.prefabnz.com/About/

2 Burnham Kelly, *The Prefabrication of Houses* (Cambridge, Mass. and New York: The Technology Press of The Massachusetts Institute of Technology and Wiley, 1951), 7.

3 Pamela Bell, "Kiwi Prefab: Prefabricated Housing in New Zealand" (M.Arch thesis, Victoria University, Wellington, 2008). Now published as *Kiwi prefab: cottage to cutting edge: prefabricated housing in New Zealand* (Auckland: Balasoglou Books, 2012).

4 Alison Arieff and Bryan Burkhart, *Prefab*, (Layton: Gibbs Smith, Publisher, 2002), 13.

without precedent, it is useful to survey a selection of examples from the history of this mode of construction, to chart its rise and fall in popularity and to acknowledge a wider building culture that has remained resistant to an ensemble approach to offsite fabrication.

John Manning: Colonial Experiments in Ensemble Prefabrication

Historically, the ambition for the complete industrialization of building fabrication arises from demand generated by unusual circumstances. Particularly fertile ground for such attempts has been that of isolated rather than established settlements.[5] While not a comprehensive panorama of the history of prefabrication, Australia's origins as a colonial outpost provides a useful reference point for comparing the development of construction by both ensemble and component. From the outset, prefabrication figured prominently in the settlement of Australia. The demands of a newly formed migrant colony far outstripped the capacity of local materials and skilled labour. In 1788, Captain Arthur Phillip's compact four-room dwelling erected on his arrival is described as "a portable house which is framed and the sides etc. of painted canvas".[6] Equally, as development continued, prefabricated components figured more prominently with timber doors and windows premade and shipped to site.[7]

Notable in early experiments in ensemble prefabrication erected in Australia is the Portable Colonial Cottage, manufactured around 1833 in High Holborn London by John Manning. Examples of colonial timber prefabrication frequently employ a system of pre-cut timber members using traditional construction techniques; the Portable Colonial Cottage is significant in the utilization of an ensemble approach to its assembly.

The structure consisted of load bearing posts spaced at three-foot centres and rebated to house standardized infill wall panels. Connections at the perimeter wall bottom and top plate were mechanically fixed using coach screws to floor framing, rafters and tie beams. The result was a structure that could be assembled with little more than a bed wrench and required no cutting or jointing of the standardized timber members.[8] The timber infill walls of the cottage were, despite the absence of a lock rail, essentially a fixed framed door made up of three rebated flush panels separated by muntin bars, stiles and top and bottom rails.

As well as being quick to assemble on site, this panellised system had the benefit of being a common construction method adding to its speed of fabrication, and in comparison to a pre-cut stud frame more spatially efficient to transport. Aesthetically, the cottage was an interesting departure from the neoclassical flourishes of other pre-cut dwellings of the time, such as Peter Thompsons

5 Gilbert Herbert, *Pioneers of prefabrication: the British contribution in the nineteenth century* (Baltimore: Johns Hopkins University Press, 1978), 2.

6 Robin Boyd, *Australia's Home: It's Origins, Builders and Occupiers* (Ringwood: Penguin, 1968), 142.

7 Herbert, *Pioneers of prefabrication*, 7.

8 Herbert, *Pioneers of prefabrication*, 7.

Emigrants' houses.[9] In Manning's cottage the elements of the prefabricated ensemble are clearly expressed without the need for decorative head casings above windows or finials common in domestic construction of the period. Manning, a builder from a yard in central London, had developed a prefabricated structural system featuring themes that modernist architecture would pursue for years to come: mass production, assembly by unskilled labour, and standardization of building components.

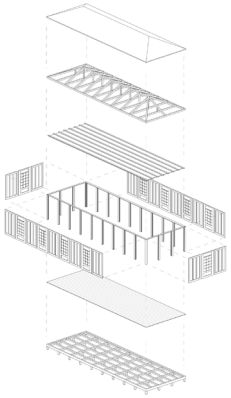

Fig. 1. Axonometric Study: Manning House for Captain Hall. Referenced from Gilbert Herbert, *Pioneers of prefabrication: the British contribution in the nineteenth century*. (Baltimore: Johns Hopkins University Press, 1978), 17.

Despite this prescience, the Portable Colonial Cottage was not without its problems. The single skin construction lacked the benefit of an insulating cavity, and, as a result, performed poorly in Australian conditions. This was not only an issue with the wall construction. The roof structure, originally draped in a treated tarpaulin and later in metal tiles fixed to timber boarding, proved unbearably hot under the compact eight foot ceilings.[10]

External factors also affected the success of the cottage. Migration to Australia had virtually come to a standstill, dropping from 33,000 migrants in 1841 to a mere 830 by 1845.[11] Not only was demand for new housing decreasing dramatically during this period, local expertise in building and fabrication was also filling the vacuum that Manning, Thompson and other fabricators had formerly exploited. Commercial mills were producing timber for domestic and international markets in New South Wales, Victoria, South Australia and Tasmania.[12] Moreover, during the period Manning was exporting his cottages to Australia traditional timber framing techniques were undergoing a phase of substantial development. Machine made nails were readily available and by 1853, after twenty

9 Herbert, *Pioneers of prefabrication*, 11.

10 Herbert, *Pioneers of prefabrication*, 17.

11 Herbert, *Pioneers of prefabrication*, 22.

12 "Australian Water Powered Saw Mills." Morawa District Historical Society and Museum, 20 January 2014. http://members.westnet.com.au/caladenia/waterSawmills.html

years of evolution, the economy of timber stud framing had been established as a vernacular carpentry technique.[13]

It is likely, even from his remote location in the Great Britain, that Manning would have been aware of the limitations of his prefabricated cottage. The poor thermal performance afforded by single-skin construction applies equally to cold climates as it does to hot. Some aspects of prefabrication, however, proved resistant to alteration and development. For example, the demands of industrial production required investment in assembly infrastructure to achieve efficiency. Retooling a fabrication yard and retraining labour is one of many potential impediments when altering ensemble off-site construction. Additionally, could an alternative solution still afford the same efficiency in transport or assembly on site? There is no evidence that reveals whether Manning wrestled with these logistical issues bound into ensemble prefabrication. What we do know is that by 1840 Manning's attention was turning to a new technology of that time, setting up an iron and wire works and offering prefabrication by component.[14]

Goodlet and Smith: Prefabrication by Component

While prefabrication as ensemble struggled in this climate, prefabrication by component continued to flourish. Significant during this period is the arrival of John Hay Goodlet as an emigrant from Leith, Scotland, in 1852. Gaining employment as a clerk with timber merchants Charles and John Smith in Melbourne at the age of seventeen, within the year he was a partner in the business.[15] In 1855 Goodlet moved to Sydney taking with him a shipment of doors, the profits from which he used to establish a sawmill on Erskine Street in Sydney. By the 1860s, trading under the name Goodlet and Smith Ltd., he had established sawmills at Ulladulla, Coolongolook and Pyrmont.[16] By 1875 the Pyrmont mill represented a complete industrialization of the process of assembling prefabricated components. Logs delivered directly by ship were cut, cured, dressed and assembled into joinery items on site. Impressively the steam-driven facility was capable of milling 50,000 feet of board a day. The boilers were entirely fed by a system of endless screws that took offcuts from the milling process directly to the furnace requiring no additional fuel source.[17] The Carpenters' and Joiners' floor was at the time the largest in the southern hemisphere. It employed some forty tradespeople and manufactured prefabricated timber items such as doors, window frames, sashes, mantel pieces and furniture.[18]

13 Miles Lewis, "Peter Bell and the Australian Stud Frame," *Architecture Australia* 74, no.7 (1985): 81.

14 Herbert, *Pioneers of prefabrication*, 23.

15 "John Hay Goodlet." Beecroft Presbyterian Church. 20 January 2014. http://www.beecroftpresbyterian.org.au/lib/exe/fetch.php/downloads:about:goodlet2.pdf

16 "Miniature terracotta tiles and cement bag, 1893." Powerhouse Museum Collection. 20 January 2014. http://www.powerhousemuseum.com/mob/collection/database/?irn=9676&search=first+class&images=&wloc=&c=0&s=0

17 "Messrs. Goodlet and Smith's Steam and Joinery Mills," *Illustrated Sydney News*, 14 November 1874.

18 "Messrs. Goodlet and Smith's Steam and Joinery Mills," *Illustrated Sydney News*.

Fig. 2. *Illustrated Sydney News*, Messrs. Goodlet and Smith's Steam and Joinery Mills, November 14, 1874.

An advertisement run in *The Illustrated Sydney News* in 1874 suggests that labour at the mill was organized around a specialisation of tasks and roles.

"By the alteration of cutters, with a variety of which each machine is plentifully provided, they may be made to perform completely different kinds of work. In the construction of window sashes and doors, alone, nearly every workman in the establishment, in some way or other, lends his aid."[19]

This industrialization of the fabrication process, division of labour and investment in manufacturing technology was to typify the growth of Goodlet and Smith for the next forty years. By the turn of the century, John Goodlet was operating a cement and tile works at Granville, a lime works at Capertee and pottery and brickworks at Surry Hills, in addition to the saw and joinery works in Coologolook and Pyrmont.[20] Product catalogues from this time reveal a range of prefabricated components that resemble very closely how an architect might specify elements for a project today. Doors, windows and joinery items manufactured to standardized dimensions, among a host of other construction elements show that even during this early period, the broader building culture in Australia was eager to adopt the time and cost saving benefits of prefabricated components.

This is not to argue that an ensemble approach to prefabricated building was completely absent during this time. Even Goodlet and Smith offered a range of eleven different pre-cut (though traditional construction) weatherboard houses, varying in complexity from a two-room workers cottage to a five-room bungalow.[21] However as the economic climate in Australia settled into a more established pattern of development the appeal of an instant prefabricated solution gave way to more traditional construction methods.

19 "Messrs. Goodlet and Smith's Steam and Joinery Mills," *Illustrated Sydney News*.

20 *Goodlet and Smith Ltd. Product Catalogue*, "Goodlet and Smith Ltd. Sydney Timber and Glass Merchants," 1902.

21 "Goodlet and Smith Ltd. Sydney Timber and Glass Merchants."

Vandyke Brothers: Ensemble Prefabrication in the Post WWII Period

In many instances experiments in ensemble prefabrication are tied to events in Australian history, accompanying dramatic increases migration and housing shortages occurring both at, regional and national levels. The gold rush of the late 1850s, provided an opportunity for the uptake of the experimental iron houses of John Walker.[22] The expansion of Victoria's rail and electrical infrastructure in the late 1940s, humorously dubbed "Operation Snail" featured experiments in prefabrication by Simms Sons and Cook of Nottingham.[23] At a national level dramatic increases in migration from Europe in the aftermath of the Second World War created a housing shortage that resulted in an unprecedented period of experimentation in prefabrication. By 1949 there were no fewer than twenty factories in Australia contributing to the industry, in total capable of producing 3540 prefabricated houses in a year.[24]

Notable amongst this group of fabricators was a family of Dutch emigrants, the Vandyke Brothers who for a short time grew to be Australia's largest ensemble prefabricator. Their patented "Sectionit" building system first came to public attention at the Sydney Royal Easter Show in 1938 where a full-scale prototype was erected for display.[25] Much like Manning's Portable Colonial Cottage a century earlier the Sectionit house was set out on a three-foot grid, however in this case the panelised construction system was structural.

Whether you buy a motor car, a sewing machine, or a radio set you want the latest in style and design. Be as modern in the selection of your builder. Have done with architecture that was new 30 or 40 years ago. Let your home be a 1937 model a home built by Vandyke Brothers.

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If you own a Block of Land we can build your home on lower-than-rent repayments.

Fig. 3. *Sydney Morning Herald*, Vandyke Brothers "Sectionit" Machine Made Homes, May 1, 1937, 14

The three by nine foot standardized wall panels were timber framed with grooves to receive jointing splines and clad both internally and externally in fibro-cement sheet that formed an insulating cavity. Externally the panel joints were finished with fibro-cement cover battens and internally with thin D profile timber beading.[26] Doors and windows conforming to the three-foot panel module were fitted on the jig during fabrication and nailed in place on site. The tongue-and-grooved cypress pine

22 Herbert, *Pioneers of prefabrication*, 46.

23 S. E. Tottenham, "Operation Snail." *Architecture: The Journal of the Royal Australian Architects* 03, no.4 (1950): 124.

24 "Mass-Produced Houses," *The Australian Women's Weekly*, 12 November 1949, 18.

25 Keith Newman, "Local Prefabrication of Homes," *The Sydney Morning Herald*, 30 June 1945, 6.

26 Newman, "Local Prefabrication of Homes," 6.

covered floor framing was fabricated in panels six feet wide and up to eighteen feet long, depending on the model of house being constructed. The exception to this was the building's precast concrete wet areas, factory cast and tiled in metal forms as a way of reducing plumbing and wet trades on site.[27] Combined with the shop assembly of all plumbing and gas services the Vandyke's Sectionit system could be assembled in one week as compared to six to eight weeks for a traditional masonry build of a home the same size.[28]

In the brief period before the outbreak of the Second World War, the Vandyke Brothers had constructed some three-hundred-and-fifty houses from their factory in Punchbowl. During the war, the factory produced a number of dwellings for war workers at Lithgow in 1942, however shortly after the completion of this project, house production virtually ceased and the firm suspended operations. [29] During wartime, regardless of building material shortages, the government was constitutionally restricted from building social housing projects for the public, with the exception of ex-servicemen and government employees. Circumventing this legislation the Commonwealth and State Housing Agreement was proposed and became effective in December 1943.[30] This enabled the government to distribute funds for social housing construction through the New South Wales Housing Commission.

In the immediate post war period, it was under this programme that the Vandyke Brothers thrived. By 1951 their factory at Punchbowl had delivered some 2,600 prefabricated homes in New South Wales alone, and employed over four hundred staff on the shop floor, with a capacity to produce thirty Sectionit Cottages in a week.[31] By 1952 however, the fortunes of the Vandyke Brothers were to change dramatically. Production capacity at the factory had been increased on the understanding that the housing commission was to award a contract to the company for one thousand new homes at a contract value of £ 2,500,000. At the eleventh hour the New South Wales Housing Commission reneged on this undertaking, perhaps more due to internal power struggles within the Labour caucus than shrewd public housing policy.[32] Ultimately the contract for 1,642 prefabricated homes was awarded to the English firm of Riley Newum despite the Vandyke Brothers being able to deliver the Sectionit Cottage for near half the cost.[33] By 1953 the factory at Punchbowl, the largest manufacturer of prefabricated homes in Australia, had gone from employing over 400 staff to a mere ten. It was a strange turn of events, considering the company director Christopher Vandyke

27 S. E. Tottenham, "House Out of Factory," *Architecture: The Journal of the Royal Australian Architects* 03, no.4 (1950): 123.

28 Newman, "Local Prefabrication of Homes," 6.

29 Newman, "Local Prefabrication of Homes," 6.

30 Boyd, *Australia's Home: It's Origins, Builders and Occupiers*, 244.

31 *The Sydney Morning Herald* , "Heffron Attacks Evatt on Housing Contract.", May 7, 1953, 3.

32 *The Sydney Morning Herald* , "Heffron Attacks Evatt on Housing Contract," 3.

33 *The Sydney Morning Herald*, "Waste on Prefabs: Federal Govt. Attacked.", April 22, 1953, 4.

had previously been appointed by the Government to travel to Europe and report on the suitability of foreign prefabricated housing for the domestic market.[34]

Conclusion: Some Assembly Required

The history of an ensemble approach to prefabricated housing reveals programmes where the fate of the construction system is wedded to the events that created the initial market demand. The rise and fall of housing supply and skilled labour corresponds to the operating capacity of companies employing techniques of prefabrication. Australia's past is littered with aborted or short lived attempts at ensemble prefabrication, Architect Arthur Baldwinson's Beaufort Home, the Myer Emporium and Commonwealth Aircraft Corporation collaboration "Myer House", to name a few.[35] While the specific details of what brought about the end of each of these industrial fabricators warrants further research, it is constructive to note within the scope of this paper some of the broader themes that inhibit the adoption of ensemble prefabrication. As these companies failed, an opportunity for the wider influence of prefabrication on building culture was lost. Beyond the intellectual property held in construction system patents, much of the productivity in prefabricated systems results from operational efficiency developed over time and refining the delivery process through experience.[36] The level of coordination involved in the transport logistics of the Victorian Rail housing program "Operation Snail" in 1948 offers an example:

> "... the longest member in a crate of roof trusses determines its shipping volume, which at over 3s. per cubic foot assumes some importance. If the offending member is transferred to a longer crate containing, say plaster sheet, freight can be saved. But the trusses are needed early on the job, so that crate would have to be delivered early and the plaster put aside until the roof is enclosed. Extensive on-site covered storage then becomes necessary if packaging is out of step with the erection sequence. This may perhaps be costlier than paying the extra freight. It may pay better to redesign the truss member with a quite expensive splice."[37]

In the uneven history of ensemble prefabrication, it is exactly this kind of fundamental knowledge of logistics that is lost. While there are clearly reoccurring tectonic themes in off-site construction, the staccato nature of the industry has not produced a widely adopted construction method. Set against this is a domestic building culture where prefabricated building components are ubiquitous, able to operate within established building trade specialisations, and less susceptible to the fluctuations of the Australian construction economy. Traditional construction in this way is the outcome of a slow evolutionary process, inherently risk-adverse but also adaptable to developments in construction technology, all be it slowly. By comparison, ensemble off-site construction is a closed system, its

34 *The Sydney Morning Herald* , "Shortage of Money," 7 May 1953, 3.

35 Boyd, *Australia's Home: It's Origins, Builders and Occupiers*, 245.

36 Tottenham, "Operation Snail." 126.

37 Tottenham, "Operation Snail," 125.

specificity as a solution is its biggest asset in terms of assembly speed, cost and reductions in skilled labour, but also its biggest impediment to being adopted within the broader building culture. Although outside the scope of Australia's experiments in domestic prefabrication, Walter Gropius' reflections on his foray into off-site prefabrication with the American General Panel Company ring true:

> "Genuine variety without monotony could have been attained if we had taken greater interest and influence in the development and design of an ever more comprehensive production of standardized, component building parts which could be assembled into a wide diversity of house types. Instead the idea of prefabrication was seized by manufacturing firms who came up with the stifling project of mass producing whole house types instead of component parts only. The resulting monotony further deepened the horror of a nostalgic, sentimental, unguided public of a prefabricated future."[38]

Gropius' objection to the mass production of a fixed housing type suggests an alternative way of framing the development of component and ensemble prefabrication. Where Burnham Kelly describes prefabrication on a continuum, at one end the individual component and at the other a complete transportable dwelling, Gropius argues for prefabrication as a suite of universally configurable components. The two positions are not viewed as distinct approaches to off-site fabrication, rather through the adaptable component an ensemble type can be reached in an open system.[39] The potential of this approach lies in the ability to retain the production efficiencies of a fixed ensemble solution while maintaining the adaptability of prefabrication by component in its application to a broader building culture. Gropius, working in collaboration with Konrad Wachsmann, was unable to realize the potential of this idea in post war America, however contemporary advances in digital design and fabrication technology may present an opportunity to take up these themes. Present-day automated manufacturing processes already have the capability to produce individually customizable housing types at a commercial scale.[40] And while the impact of advances in digital design and fabrication technology are yet to fully play out on domestic building culture in Australia, its history in prefabricated ensemble construction should serve as a cautionary note to designers and manufacturers.

38 Gilbert Herbert, *The Dream of the Factory Made House* (Cambridge, Mass.: MIT Press, 1984), 2.

39 Herbert, *The Dream of the Factory Made House*, 38.

40 Colin Davies, *The Prefabricated Home* (London: Reaktion Books, 2005), 189.