





Government of South Australia

THE APARTMENT CONSTRUCTION COST DEMONSTRATION PROJECT **RESEARCH PROJECT**

A BANK

"AN AFFORDABLE PLACE TO LIVE IS MORE THAN JUST HOUSING AND HOUSEHOLD COSTS. IT INCLUDES THE NEIGHBOURHOODS THAT ARE CREATED AND THE COMMUNITIES THAT EMERGE. IT IS ABOUT THE CONNECTIONS THAT ARE SUPPORTED. SERVICES THAT ARE PROVIDED AND THE LIFESTYLES THAT ARE SUSTAINED"



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In partnership with our **Builder Partner**



And our

Design Partner Lead Studio Nine Architects



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EXECUTIVE SUMMARY

The Apartment Construction Cost Demonstration Project was an innovative and collaborative partnership between Renewal SA and the private development sector to investigate contemporary design and construction approaches to minimise building costs.

Following a public expression of interest process run by Renewal SA in mid-2014, multiaward-winning firm Mossop Construction + Interiors was appointed as the builder partner and leading Adelaide architectural firm Studio Nine was chosen as the design team leader.

Consistent with State Government urban planning policy, identifying more costeffective construction methodologies for multi-storey residential buildings supports higher urban density and urban infill within the middle ring suburbs.

Industry and Renewal SA experience shows that typical apartment construction rates make it challenging to recover construction costs from the selling prices supported by the market outside of the CBD, near CBD locations, beachfront and other selected high amenity nodes within metropolitan Adelaide. Typical apartment construction rates are often more than double the cost per square metre of a two-storey detached home. Analysis by Renewal SA indicated that a total project construction cost between \$1800 and \$2000 per m² (GST inclusive) would need to be achieved to ensure commercially viable apartment developments of four storeys. This became the target construction cost range for the project which compares favourably to historical apartment build costs between \$2400 and more than \$3000 per m² (GST inclusive).

The demonstration project highlights the exciting potential for cost savings and improved design outcomes through early and ongoing collaboration between the design team and the builder.

The preferred construction system determined by the project team was a combination of an insulated concrete form (ICF) product for the external and internal walls and a pre-cast concrete floor cassette system for the floors.

The system achieved the target cost per square metre rate, with a market-tested price of \$1974 per m2 (GST inclusive) or \$1795 per

m² (GST exclusive) for the demonstration project. It is important to note that depending on market conditions and supplier relationships, pricing can vary. Indeed, the project revealed a plethora of new materials and emerging systems continually coming to market. Ultimately, the most cost effective system will depend on the developer's specific apartment design.

Based on the project team's experience, adopting some or all of the following principles were found to be effective in reducing construction costs for the demonstration project:

- Modular layout with straight and aligned walls on a grid pattern at span widths of the structural/ flooring systems
- Reducing the volume of material by designing all load-bearing walls to the ground (using direct load paths) to avoid secondary framing
- Co-location of services to allow floors to be easily 'stacked'
- Optimal spans of around three metres to allow a wider choice of materials and to reduce waste during construction
- Designing all bedrooms, kitchens and bathrooms to be of similar size and layout to maximise replication and reduce costs
- Rationalise room orientation to have direct light and ventilation
- Easy fire compartmentalisation
- Compact common areas (which will also reduce community corporation costs)
- Moving wet areas to external walls of apartments to minimise noise-reduction costs
- Reduced building footprint
- No roof plant
- Prefabrication such as bathroom pods, pre-built internal and external walls, and floors.

Summing up: this report does not propose a single solution to every building cost challenge. Rather, it demonstrates a logical step-by-step process whereby developers can assess options in terms of design, material selection, construction methodology, site influences and building layout. The methodology outlined in this report can be applied to the construction of any multistorey apartment building. "GIVEN THIS INDUSTRY-WIDE CHALLENGE, TO FULLY ADDRESS THE ISSUES OF HOUSING AFFORDABILITY AND CHOICE, PARTNERSHIPS BETWEEN THE PRIVATE, GOVERNMENT AND NOT-FOR-PROFIT SECTORS ARE REQUIRED TO IDENTIFY INNOVATIVE AND CREATIVE NEW SOLUTIONS"



THE REPORT

This report covers the learnings from the process of research, design development and documentation. It consists of this Report Summary, and includes two supporting sections: Part A – Lessons Learned and Part B – Case Study.

"Why we did, what we did"

1. Delivering housing affordability for Adelaide

The South Australian Government's urban planning and development aspirations for the next 30 years aim to ensure that Adelaide remains a city that is liveable, sustainable and productive.

The State has been a leader in housing affordability: a key strategic priority for the government continues to be ensuring that more South Australians have an affordable home in a location of their choice. Housing represents the single largest expense in the average household budget and, for most South Australians, their quality of life is influenced by the rising costs of housing, transport and utilities.

Ultimately, the planning of our neighbourhoods and the design of our homes can also help reduce the cost of living and improve our general wellbeing.

The Apartment Construction Cost Demonstration Project is an innovative and collaborative partnership between Renewal SA and the private development sector to investigate contemporary design and construction approaches to minimise building costs.

The State Planning Strategy forecasts a requirement for at least 38,700 new affordable homes in Greater Adelaide and 7,000 new affordable homes in nonmetropolitan areas of the state over the next 30 years.

Under the State Government's planning vision, the majority of new homes are to be built within existing urban areas to better utilise existing infrastructure and to enable ease of access to transport, jobs, education and other services and facilities. Projections, however, indicate restricted housing choices and a shortfall of well-located dwellings and affordable dwellings for rental and purchase suited to an aging population or those with disabilities.

Identifying more cost-effective construction methodologies for multi-storey residential buildings supports higher urban density and urban infill within the middle ring suburbs.

With this in mind, a key objective of the demonstration project is to deliver a marketbased methodology that has the potential to be replicated to achieve lower construction costs for a four-storey apartment building than have historically been achieved in Adelaide.

Industry and Renewal SA experience shows that typical apartment construction rates make it challenging to recover construction costs from the selling prices supported by the market outside of the CBD, near CBD locations, beachfront and other selected high amenity nodes within metropolitan Adelaide.

Given this industry-wide challenge, to fully address the issues of housing affordability and choice, partnerships between the private, government and not-for-profit sectors are required to identify innovative and creative new solutions.

As part of the contemporary thinking that is required, Renewal SA embarked on this demonstration project to design and construct a four-storey apartment building in a middle ring suburb that delivers a commercial return and does not require a subsidy to achieve a selling price for each apartment that is market responsive.

Industry and Renewal SA experience shows that typical apartment construction rates are often more than double the cost per square metre of a single-storey detached home. Analysis by Renewal SA indicated that a total project construction cost between \$1800 and \$2000 per m² (GST inclusive) would need to be achieved to ensure commercially viable apartment developments of four storeys. This became the target construction cost range for the project which compares favourably to historical apartment build costs between \$2400 and more than \$3000 per m² (GST inclusive).

2. Sharing the learnings

Benefits experienced by Renewal SA of the Apartment Construction Cost Demonstration project are intended to be communicated by Renewal SA and this report is the first of a number of initiatives to share the learnings.

Disseminating the learnings of the demonstration project will help to overcome the current high apartment construction costs which are a barrier to the delivery of this form of housing in the broader Adelaide market.

Renewal SA intends to communicate the following types of project learnings:

- the collaborative benefits of builders and designers working together;
- design efficiency;
- cost and buildability of varying construction methods;
- how material selection impacts upfront building costs for developers; and
- the life cycle cost to future apartment owners.

The purpose of this report is to provide a update to industry on the demonstration project and to stimulate ideas for future cost effective housing projects currently underway or in early planning by the private sector.

The report is not intended in any way to be a definitive 'how to' guide on apartment building design and construction. The research and design documentation phase demonstrated that the cost of floor and walling systems and construction materials can vary significantly depending on market supply and demand, the buying power of the builder and the relationship between the builder and a supplier.

No single building system, construction methodology or material had a major advantage – although some are clearly more cost and time effective than others for a fourstorey apartment building.

Nonetheless, the project clearly demonstrates the benefits of flexible thinking when assessing the variety of floor and walling systems and materials available for multistorey residential construction. This openminded approach is especially important given the continual release of new technologies and materials to market. Even more significantly, the demonstration project shows the exciting potential for cost savings (and better design outcomes) through early and ongoing collaboration between the design team and the builder.

3. Paramount objectives

The demonstration project, managed by Renewal SA, has two paramount objectives to benefit industry initially and ultimately homebuyers:

- Deliver an apartment building for public sale at market price points for inner/ middle ring metropolitan locations, in a manner that has the potential to be replicated. To do this, the project set out to achieve a target building construction cost that results in a significant reduction in total project cost.
- 2. Share the learnings with the construction and development industry of how such a reduction was achieved – particularly around techniques and practices for building layout, site layout, construction methodology and choice of materials.

In order to deliver these paramount objectives, the following project scope was established:

- Investigate alternative construction techniques and design efficiencies based on residential/ domestic building approaches to achieve lower building construction costs than has historically been achieved potentially using timber or steel framing systems (or other building systems);
- Demonstrate design innovation incorporating sound sustainability principles;
- Deliver demonstration projects within an existing Renewal SA project;
- Meet the State Government's 15% affordable housing requirement;
- Ensure any newly-created intellectual property is available to the construction and development industry;
- Collaborate with the broader private sector development industry by direct engagement with firms involved in apartment project delivery and via industry representative bodies.
- Proceed to on-site delivery only on the basis of meeting target construction costs (and therefore a total development cost) and being market based to achieve a commercial return so that the project has the potential to be replicated.

4. Industry involvement

Renewal SA appointed an Industry Reference Group (IRG) representing the Urban Development Industry Association, Housing Industry Association, Property Council, Master Builders Association, Australian Institute of Architects, Planning Institute of Australia and the Australian Institute of Building Surveyors.

The role of the IRG is to provide input into the progress of the demonstration project, as well as ensuring the formal exchange of learnings from the project site. Where relevant, the IRG will share contributions from industry on cost effective medium-density apartment development. The IRG provided guidance throughout the research and design documentation phase of the demonstration project and will continue to be involved if the project proceeds to the construction phase.

The IRG first met in March 2014 to provide guidance on key project decisions such as the target square metre rate and the height of the proposed building.

"What we did"

5. Project Scope

The demonstration project was managed by Renewal SA and involved the selection of a builder partner and a design partner from the private sector. Following a public expression of interest (EOI) process run by Renewal SA in mid-2014, multi-award-winning firm Mossop Construction + Interiors was appointed as the builder partner and leading Adelaide architectural firm Studio Nine was chosen as the design team leader.

The project scope comprised the following four stages:

- Stage 1A (builder partner selection): first EOI process to select a preferred Proponent with the expertise and capacity to build a residential apartment building at Renewal SA's Woodville West development.
- Stage 1B (design team selection): second EOI process to select a design team including civil, structural and mechanical engineering specialists and other relevant construction consultants.
- Stage 2 (research and design development phase): collaborative stage between builder partner, design team and Renewal SA requiring extensive research and

development activity to determine costeffective building technologies and cost engineering. Anticipated outcome will be construction-ready documentation to achieve the target cost-per-square-metre construction rate.

 Stage 3 (construction and selling phase): on-site delivery of civil and apartment construction subject to approvals.

The construction cost target of \$1800 to \$2000 per m² (GST inclusive) is based on anticipated retail selling prices for apartments in the high \$200,000s to low \$300,000s that have been established in Stage 1 of Renewal SA's The Square at Woodville West medium density residential project.

The height of four storeys was chosen after industry advice through the Industry Reference Group that this would represent a viable demonstration project given existing experience in being able to achieve threestorey apartment buildings at approximately \$1800 per m² (GST inclusive).

As part of the scope, Renewal SA resolved that if the project achieves the right price and the right design, Renewal SA would then determine the method of delivery for construction.

A site in Renewal SA's project, The Square at Woodville West, was chosen as it represents a typical middle ring suburban location within metropolitan Adelaide.

Since the completion of the public EOI process in September 2014, the project team has completed the research and design documentation phase by June 2015, culminating in this report. Following all necessary statutory approvals, construction of the apartment building began in November 2016 and is scheduled for completion in late 2017.

6. Total project construction cost

For the purpose of the demonstration project, total project construction cost is defined as:

The combined cost of site works; at-grade car parking; building services and infrastructure; building cost; landscaping; builder's margin and overheads and including GST. The total project cost excludes design and consultants' fees.

"What we learned"

7. Key findings

Benefits of collaboration

One of the key outputs from the research phase of the project was the confirmation by the project team of the benefits of collaboration. The demonstration project does show the exciting potential for cost savings and improved design outcomes through early and ongoing collaboration between the design team and the builder.

Design findings

Collaborative input between the designer and builder leads to efficiency in design. Investigations include:

- a. Modular layout & co-location of services
- b. Reducing material volume by designing load-bearing walls to ground
- c. Optimal spans results in a wider materials choice and reduced waste
- d. Designing rooms to be the same size and layout maximises replication
- e. Rationalise room orientation to have direct light and ventilation
- f. Easy fire compartmentalisation & compact common areas
- g. Moving wet areas to external walls to minimise noise-reduction costs
- h. Reduced building foot print & no roof plant

Construction findings

Potential cost savings through early and ongoing collaboration between the design team and the builder.

- a. The cost of floor and walling systems and construction materials can vary significantly depending on:
 - market supply and demand
 - the buying power of the builder
 - the relationship between a builder and a supplier
- No single building system, construction methodology or material had a major advantage - although some are clearly more cost-effective than others for a fourstorey apartment building.

- c. Work to date clearly demonstrates the benefits of flexible thinking when assessing the variety of floor and walling systems and materials available for multistorey residential construction.
- d. An open-minded approach is especially important given the continual release of new technologies and materials to market.

Lessons learned by the process

The following lessons learned have been derived from the project team's experience during the research and design development phase. These lessons learned can be considered a useful guide for builders and architects aiming to achieve more cost effective construction of medium rise apartment buildings. The following steps represent a well-defined process to achieve a nominated target construction cost:

- a. Commitment to collaborative process: establishing the earliest possible collaboration between the design and builder teams is critical to success.
- b. Establishing the project success factors: once you have agreed your project success factors, document them and provide to every team member as a continual reminder of the big picture.
- c. Implementing a 'first principles' approach: start with a blank sheet of paper and don't approach the task in a certain way because "that's the way its always done".
- d. Determining cost centres: accurately determine the true cost of each building element and focus on those elements where maximum savings can be achieved.
- e. Developing the concept design: avoid being "blinded" by the detail and always find the solution that delivers the big picture.
- f. Value engineering: start and continue with an open mind always reviewing the design for building efficiency and cost savings.
- g. Interim Stop / Go Assessment: make sure the design and costs are absolutely aligned to the project objectives and is market responsive.
- Nalidating the concept design: even late in the design and tendering process, be willing to substitute a particular product with another of similar or better performance characteristics.

Commercial assessment

Consistent with the EOI requirement for the demonstration project to be commercially replicable, a return on investment (ROI) of 16% to 20% was advised by the IRG to be a suitable benchmark.

Based on the final fully documented design of the preferred construction option, with a tendered price and independent appraisals of each apartments selling prices, an ROI within this range has been achieved for the demonstration project.

8. Research phase

The project team identified that the following research areas would be investigated as potential ways to improve design and to reduce construction costs:

Design

- Efficiency: floorplans eliminating wasted space minimises building area and allows 'stack-ability' of floors to achieve vertical load paths and economical service runs.
- Standardisation: reduces the risk of errors during construction (and therefore cost), making construction easily replicated.
- Prefabrication: bathroom pods, pre-built internal / external walls and floors.

Construction

In addition to these design considerations, the following four principles were adopted in the demonstration project to reduce construction costs:

- Materials and 'de-materialisation' using less materials and layers, pre-fabrication to speed up on-site erection and assembly, whilst including considerations such as durability, fire and acoustic properties and reduced labour and waste.
- Labour reduced number of trades on site, better work health and safety, less travel and fuel. Sequencing of trades for less wet trades and re-attendance.
- Ease of construction reduced time, less equipment hire and lower preliminaries.
- Reduced maintenance costs providing in-built sustainability based on lower life-long maintenance costs by using pre-finished and durable materials.

Investigations and assessments

Led by builder partner Mossop, the design team coordinated by Studio Nine undertook the following investigations and assessments:

- Six Research workshops
 - 13 supplier presentations
 - 11 wall & floor systems
 - 17 cladding systems
- Site visits
 - Insulated concrete formwork
 - Modular prefabricated systems
- Identification of cost centres
 - Floor and support systems 10-14%
 - External wall systems 9-12%
- Design development
 - Continual evaluation of alternatives
 - Open minded/ flexible thinking
 - Continual review & collaboration

9. Construction cost reduction

Based on the project team's experience and learnings, adopting some or all of the following principles were found to be effective in reducing construction costs for the demonstration project:

- a. Modular layout with straight and aligned walls on a grid pattern at span widths of the structural/ flooring systems
- b. Reducing the volume of material by designing all load-bearing walls to the ground (using direct load paths) to avoid secondary framing
- c. Co-location of services to allow floors to be easily 'stacked'
- d. Optimal spans of around three metres to allow a wider choice of materials and to reduce waste during construction
- e. Designing all bedrooms, kitchens and bathrooms to be of similar size and layout to maximise replication and reduce costs
- f. Rationalise room orientation to have direct light and ventilation
- g. Easy fire compartmentalisation
- h. Compact common areas (which will also reduce community corporation costs)
- i. Moving wet areas to external walls of apartments to minimise noise-reduction costs

- j. Reduced building footprint
- k. No roof plant
- l. Prefabrication such as bathroom pods, pre-built internal and external walls, and floors.

10. Preferred design



Visual 1: The site plan of the demonstration project

The preferred design comprises a 20-apartment lifted building of four storeys with:

- total floor area of 1985m²
- 583 m2 at-grade car park with 24 bays
- total site area of 1390m²
- exclusively residential
- compliant with relevant City of Charles Sturt Development Plan
- main street frontage with vehicle access from side lane
- 20 undercover carports each with a storage locker
- 5 apartments on each of the 4 levels
- modular design based on optimal span distances of differing structural systems
- saleable area to gross building area represents 87% efficiency

11. Apartment layouts

The building features a mix of one and two bedroom apartments based on anticipated market demand with an efficient use of space with pleasant spatial flows as follows:

Туре	Floor Area (m ²)	Number	Mix	Anticipated Retail Price
1 bed	54.2	2	10%	From \$265,000
1 bed + study	56.5	2	10%	\$310,000 - \$320,000
2 bed	64.2 to 70.5	8	40%	\$315,000 -\$330,000
2 bed + study	69.7 to 71.9	8	40%	\$325,000- \$342,000

Table 1: Apartment details



Visual 2: Floor plans of the demonstration project

In addition to the above floor areas, each apartment has a minimum $12m^2$ of balcony space and about $8m^3$ of external storage space located either in the carport parking bays, as separate storage unit within the building envelope, or incorporated in ground floor private open space.

12. Construction options

To determine the preferred construction methodology the project team, led by Mossop evaluated a wide range of material and construction systems. These were assessed on availability, buildability and cost with more expensive options not considered further. As part of this process, estimated costs were derived for eight options based on the final design.

Using the criteria of availability, buildability and cost, the top three performing options were market tested by Mossop which conducted a tender process based on fully documented drawings and specification.



The Preferred Option

The preferred construction system determined by the project team was a combination comprising an insulated concrete form (ICF) product for the external and internal walls and a pre-cast concrete floor cassette system for the floors.

It is important to note that depending on market conditions and supplier relationships, pricing can vary. The most cost effective system will depend on the developer's specific apartment design. For the demonstration project the ability to substitute key selected materials offered the advantage of not being locked in to any one product, allowing for ease of replacing one item for another with minimal impact on documentation.

The project team resolved that the pairing of the products used provided the following buildability advantages for the demonstration project:

- flexibility in design options for the wall profile
- achieves acoustic thermal and fire rating requirements
- meets de-materialisation strategy to reduce the amount of materials
- lowest floor to floor height to reduce building height

- satisfies BCA requirements without supplementary materials
- cost effective outer skin
- ease of construction

The preferred construction system met the target cost per square metre rate achieving a market tested price of \$1974 per m² (GST inclusive) or \$1795 per m² (GST exclusive) for the demonstration project.

The cost analysis becomes more favourable when the carpark and landscaping costs of the development are excluded from the overall building cost, reducing the rate to \$1870 per m2 (GST inclusive) or \$1700 per m2 (GST exclusive) based only on the building cost and area.

Other options considered

The following two other options were also market tested, based on fully documented designs for the demonstration project:

Option 2

ICF walling and pre-cast concrete floor cassette system flooring. The rate achieved was \$1985 per m² (GST inclusive) or \$1805 per m² (GST exclusive) (based on an alternative ICF proprietary product than for option 1).

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Option 3

Precast concrete external wall frames and ICF internal walls with pre-cast concrete floor cassette system flooring. The construction rate for this system was \$2028 per m² (GST inclusive) or \$1845 per m² (GST exclusive).

The following five remaining options were not market tested. A preliminary cost estimate based primarily on floor and walling costs (which typically represent the largest cost centre expense at around 30% of the total building cost) indicated that none of these options were at or below the target construction rate for the demonstration project:

Option 4

Precast concrete external walls with ICF party walls and pre-cast concrete floor cassette system: \$2006 per m² (GST inclusive) or \$1825 per m² (GST exclusive).

Option 5

Hybrid framing using ICF and pre-cast concrete floor cassette system using a transfer slab and timber elements to create a heavyweight base with lightweight upper levels: \$2059 per m² (GST inclusive) or \$1870 per m² (GST exclusive).

Option 6

Hybrid four storey timber construction with sprinklers and including ICF and lightweight timber construction: \$2060 per m² (GST inclusive) or \$1870 per m² (GST exclusive).

Option 7

traditional precast concrete and suspended slab: \$2267 per m² (GST inclusive) or \$2060 per m² (GST exclusive).

Option 8

Brick veneer with structural steel frame and concrete floors: \$2344 per m² (GST inclusive) or \$2130 per m² (GST exclusive).

Alternative options

a) Prefabrication

As part of the consideration of options, the project team assessed the merits of prefabricated bathroom pods as a way of reducing onsite construction time and cost. Based on the selected design it was determined that such prefabrication did not provide any advantage:

- not cost competitive (against traditional trade approach)
- issues with fire integrity and penetrations of single occupancy units (of services and pipework)
- accessibility of levels (step up into the bathroom pod)
- increased material use (double up of floors on floors).

b) Cross Laminated Timber

Cross Laminated Timber (CLT) was considered by the project team at an early stage of the evaluation process, however subsequent supplier advice was that it was not cost effective in a compact four-storey building.

While CLT offers impressive lightweight strength and rapid on-site construction, the supplier advised that it does not become cost effective unless used in higher rising buildings comprising in excess of 70 to 80 apartments.

c) Analysis of under-croft parking options

Although the EOI requirement was for atgrade car parking, under-croft and part under-croft car parking options were considered at the request of IRG members to determine whether they would be costeffective for the Woodville West site. On the basis of the construction costs versus land value, the underbuilding or part underbuilding car parking was not considered as viable as the at-grade car parking option because land values at the subject site were considered less than the cost of under-croft & basement parking. Underbuilding car parking establishes two grids; the car park grid and an apartment grid that do not align. Transfer slabs and/ or beams incur costs that are not required with the direct load path model in addition to a substantially greater cost per carpark constructed.

The provision of at grade parking is a solution that has been used in a number of other recent private apartment buildings in inner suburban corridor locations in Adelaide, further supporting the projects decision to use this a basis for comparing costed construction options with the car park at grade.

13. Summary

The project delivers a market-based and commercially-replicable methodology to achieve lower construction costs for a fourstorey apartment building than historically seen in Adelaide.

The project has also revealed a plethora of new materials and emerging systems continually coming to market. For the demonstration project, the ability to substitute key selected materials offered the advantage of not being locked in to any one product, allowing for ease of replacing one item for another with minimal impact on documentation.

While this report does not propose a single solution to every building cost challenge, it does demonstrate a logical step-by-step process whereby developers can assess options in terms of design, material selection, construction methodology, site influences and building layout. This methodology can be applied to the construction of any multistorey apartment building. 18

"SUCCESSFUL PROJECT MANAGEMENT IS TYPICALLY A FINE BALANCE BETWEEN MAKING THE MOST OF PAST EXPERIENCE WHILE ALLOWING ROOM FOR FRESH THINKING"

PART A – LESSONS LEARNED

The Lessons Learned section forms part of the suite of documents detailing the Apartment Construction Cost Demonstration project which include the Research Report & Summary and Part B – Case Study.

The diagram below outlines the process flow chart of the research and design documentation phase for the project. It soon became evident during this phase project that achieving the nominated square metre rate of \$1800 to \$2000 per metre (inclusive of GST) was an iterative process involving the builder and design team proposing design and material solutions and the builder partner then evaluating and costing these against various construction systems. As a way of moving forward to a final preferred design and construction methodology, the project team developed the following eight-step process as a logical framework to achieve the project objectives of 'right design at the right price'. Each step has a series of actions which deliver critical information as outlined.



A. Commitment to collaborative process

A fundamental principle behind the demonstration project was the determination to have a true collaborative partnership from the earliest possible stage between the design and build teams. From the project team's perspective, this commitment to a collaborative process resulted in the best possible design outcome at the most competitive construction price.

The experience of Renewal SA, Studio Nine and Mossop Construction + Interiors in the design and documentation stage of the demonstration project has confirmed the many benefits of collaborating together at the earliest opportunity in an "open book" partnership.

In the case of the demonstration project, Renewal SA undertook the following **actions** to achieve collaboration:

- Conduct separate but concurrent Expression of Interest (EOI) processes to engage a suitably qualified design team and a building partner. The building partner was selected first in order to provide input into the selection of the design team, given that the focus of the demonstration project was achieving a cost effective construction methodology.
- 2. Established an Industry Reference Group to provide high level guidance on aspects such as 'build-ability' of multi-storey apartment buildings, latest available technology for cost-effective construction and insights into market expectations on apartment products.
- 3. As part of the EOI process, as a mandatory requirement, tenderers had to state whether they would agree to work in a collaborative manner throughout the project.
- 4. Another requirement in the EOI process was for the design team and the building partner to submit their preferred work schedule to deliver a truly collaborative approach. Renewal SA then developed a final work schedule in agreement with the design team and the building partner.

This collaborative approach delivered the following **benefits:**

- Comprehensive and rigorous value engineering based on an iterative process between Studio Nine, Mossop and Renewal SA with guidance from the Industry Reference Group.
- Access to information and investigation of a wide range of building products and construction technologies.
- Shared learnings in real time between the design team and the building partner on the most cost-effective construction approaches and use of materials.

Key lesson

Establishing the earliest possible collaboration between the design and builder teams is critical to success.

B. Establishing the project success factors

Every project has "a big picture" outcome and it is therefore critical to accurately interpret the brief to fully understand the vision and key objectives: this close examination will reveal the true success factors.

For the apartment demonstration project, the vision was far beyond the numerical EOI parameters such as a four storey apartment building with 20 dwellings for a construction rate of between \$1800 and \$2000 per square metre (GST Inclusive).

It was clear the brief was demanding construction of a marketable, quality product – not just a building that achieved the target construction rate and required dwelling yield, yet failed on liveability and aesthetic criteria. A further challenge was that the project had to deliver a commercially repeatable building that did not rely on government subsidy or a premium beachside or CBD location.

Actions

Renewal SA undertook the following actions as part of the demonstration project:

- Early consultation with the Industry Reference Group to determine the 'buildability' of a quality apartment building at the nominated construction rate of \$1800 to \$2000 per square metre (GST Inclusive). The IRG's advice – adopted by the project team – was that the rate was achievable for a four-storey development of 20 dwellings as industry experience had already demonstrated that a threestorey building could be built in this price range.
- Continually referring to statutory requirements around the Building Code of Australia and the local Development Plan (which in this case was the City of Charles Sturt – Woodville West Policy Area) to ensure the evolving design met both the brief and these planning criteria.
- An early decision by Renewal SA, Studio Nine and Mossop to refer to the existing NSW apartment design code (SEPP 65) which provided invaluable advice on such aspects as sustainability, liveability, economic use of space and accessibility.
- 4. Notwithstanding the above point, the project team adopted a 'first principles' approach to design to ensure complete alignment with the brief and the final outcome.

Benefits:

Renewal SA experienced the following benefits for the demonstration project by undertaking the above actions:

 The final design fully addresses the brief and delivers on the project's success factors and vision.

Key lesson

Once you have agreed your project success factors, document them and provide to every team member as a continual reminder of the big picture.

C. Implementing a 'first principles' approach

Successful project management is typically a fine balance between making the most of past experience while allowing room for fresh thinking. In the case of the demonstration project, Renewal SA had engaged two experienced and highly capable teams in Studio Nine and Mossop. The challenge was to benefit from their prior experience in multi-level building design and construction without being constrained from investigating new materials and alternative construction methodologies.

Critical to the first principles approach is the following behaviour: not to make assumptions and rely too much on previous experience. It is important to keep an open mind and think flexibly about selecting personnel, construction systems and materials.

The challenge of the project was to construct a quality apartment building that would enable the sale of apartments at an affordable price points in the high \$200,000s to low \$300,000s whilst still provide a commercial return on investment. The more typical development scenario is to identify a particular market segment or location to maximise return and not base the entire project on achieving affordable price points. As a consequence the project team adopted a first principles approach to meet the challenge.

Actions

Renewal SA undertook the following actions as part of the demonstration project:

- Given the affordable price point for each apartment (which for this project was a range from the high \$200,000s to low \$300,000s) work backwards to determine the target square metre construction rate to ensure a commercially viable project
- 2. Selecting suitably experienced and qualified design and building partner
- 3. Provide key design and project objective criteria to the consultants as a basis for a detailed brief
- 4. Appreciate the need to investigate the main costs centres of apartment construction.

- 5. Accurately determine current market price points and purchaser expectations instead of relying on past or anecdotal information
- 6. Identify the minimum design areas for the apartment building that meet acceptable liveable criteria and market demands.

Benefits

Renewal SA experienced the following benefits for the demonstration project by undertaking the above actions:

- A meaningful target for return on investment
- Reducing project risk and maximising project outcomes by having the most appropriate personnel
- A complete understanding of the key cost drivers to be targeted in the value engineering phase
- Delivery of a completed apartment building at the "right price" (construction costs and retail price points) and the "right design" (a quality, aesthetically pleasing apartment which is a desirable place to live).

Key lesson

Start with a blank sheet of paper and don't approach the task in a certain way because "that's the way its always been done".





D. Determining cost centres

Consistent with the 'first principles' approach outlined previously, the project team researched existing apartment building projects throughout Australia that offered potential insights that could be applied to the demonstration project; assessed new materials available on the market; and carefully considered the key drivers of construction cost saving. Based on the building partner's previous experiences of similar projects, a 'cost centre' list was established detailing the percentage each building element is of total construction cost (refer below).

Identification of 'big ticket items' enabled the design team to quickly target areas where it was thought the greatest potential savings could be made.

Based on advice from Mossop in relation to four and five storey apartment building, it was determined that construction costs account for about 65% of the cost with the remaining 35% comprising land, design consultants' fees, civil works, holding costs, landscaping and marketing.

As some two-thirds of costs relate to construction, the project team resolved to focus on the following construction-cost drivers as a focus for future cost reduction effort:

- Floor and support systems 10-14%;
- External wall systems 9-12%;
- Preliminaries 7-9%;
- Internal walls 7-8%;
- Plumbing and sanitary ware 6-7%;
- Electrical 5-8%;and
- Substructure 4-5%.

Considering the above cost centres, the project team spent significant time in assessing floor and wall systems as these had the potential to deliver the biggest cost savings. In all, around 30 floor, wall and cladding systems were evaluated by the project team.

It is important to note that these construction cost 'hot spots' will vary from one building project to another: so one of the key messages from this project is the value in identifying the cost centres with a view to then concentrating effort where the greatest savings are likely to be made.

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Visual 4: First principle concepts

Actions

Renewal SA undertook the following actions as part of the demonstration project:

- Determine development and design cost centres (with an initial focus on floor and wall prices and rates as these typically represent 30% of construction cost).
- 2. Reducing building waste by standardisation and 'de-materialisation' (reducing material layers by selecting materials with multiple uses) strategies.
- 3. Workshops to evaluate materials and construction systems.
- 4. Work on the basis that the design process is an iterative one.
- 5. Value engineering as an iterative process of cost management and outcome-focussed design.

Benefits

Renewal SA experienced the following benefits for the demonstration project by undertaking the above actions:

- Meaningful preliminary cost estimate
- A concept design that is capable of delivering on the success factors
- Ability to lodge for planning approval at concept design stage
- Provides the opportunity to investigate and discover innovation.

Key Lesson

Accurately determine the true cost of each building element and focus on those elements where maximum savings can be achieved.

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Visual 5: Sample of cost centres

E. Developing the concept design

Given the approach and considerations so far, at this point the concept design should start to take shape. This brings together the information derived from the previous steps:

- Commitment to a collaborative process
- Establishing the project success factors
- Implementing a first principles approach
- Determining cost centres

Good design outcomes are the result of exploring different options. This includes the importance of considering site specific variables - site location and configuration influencing site efficiency; the area of land necessary to accommodate the building, carpark and open space requirements; permissible heights and boundary setbacks in accordance with council development plans; proximity of any significant trees; how water pressure and flow could impact fire equipment & safety. All of these will impact the design and ultimately the cost.

The process of design was also an iterative process of research into material selection and construction methodology. This approach delivered two important outcomes:

Efficiency

efficient simple floorplans eliminating wasted space minimises building area and allows 'stack-ability' of floors to achieve vertical load paths and service runs.

Standardisation

reduces the risk of human error during construction (and therefore cost) making construction easily replicated.

Industry experience typically shows that 30% of all construction materials delivered to site are wasted due to non-standardised design and units of material or construction systems. Using Mossop's understanding of construction and Studio Nine's design expertise, a key learning of the project was the need for an iterative process to determine the most cost-effective design and building solution.

Actions

Renewal SA undertook the following actions as part of the demonstration project:

- 1. Analyse the site to deliver maximum site efficiency for building and car park layout
- 2. Modular layout with straight and aligned walls on a grid pattern
- 3. Maximise direct load paths to avoid secondary framing
- 4. Co-location of services to allow floors to be easily stacked
- 5. Smaller spans of around 3 metres to allow a wider choice of materials
- 6. Produce floor plan concepts in preparation for planning application lodgement
- Designing consistent configuration of bedrooms, bathrooms and kitchens on all floor plates
- 8. Ensure rooms are designed with access to natural ventilation (windows) and doors that make the most of direct light and fresh air
- 9. Ensure a dematerialisation strategy is adopted to reduce excessive layering of materials throughout the design
- 10. Investigating prefabrication options as a way of reducing on-site construction costs.

Benefits:

Renewal SA experienced the following benefits for the demonstration project by undertaking the above actions:

- Up to 30% reduction in building waste delivering significant cost savings (materials, labour and waste disposal) as well as environmental benefits
- Modular sizing leads to cost savings through reduced labour and waste
- Highly efficient design.

Key Lesson

Avoid being "blinded" by the detail and always find the solution that delivers the big picture.





Visual 6: Concept workings

F. Value engineering

A key principle of the apartment demonstration project was for the builder and design team partners to actively collaborate throughout the research and design development phase. This participation required each partner to operate in a joint 'open book' work-up of construction costs to determine trade package breakdown costs.

In practical terms, this meant that once the preliminary concept was drafted by Studio Nine, it was then given to Mossop to analyse from a 'build-ability' and cost perspective. Mossop began this process by evaluating the proposed superstructure (comprising walls and floors) then advanced to more detailed aspects such as interior layouts, efficient colocation of services, building management systems (such as waste management) and internal and external finishes (including appliances and equipment).

The project team found that the best way of achieving value engineering was to collaborate in the following manner:

- Identify areas to be targeted for cost savings in the design and layout of the building including but not limited to: building layout; individual apartment layout; minimising void areas; choice of materials, construction methodologies and practices; building services layout; at-grade car park design; and compliance with relevant statutory requirements.
- These desktop savings were then used to prepare detailed design.
- As each level of detailed design was progressed they were further examined and reviewed for potential additional savings based on "buildability" and efficiency.
- This leads to final design and documentation to enable full market costing of construction-ready drawings.

Actions:

Renewal SA undertook the following actions as part of the demonstration project, in an iterative process, whereby the builder and design team continually reviewed the evolving building design with a focus on:

 Value engineering of all major elements of the design including wall and flooring systems, external site works, building services, external and internal finishes and building management.

- 2. Ensuring an appropriate timing for a 'stop/ go' decision on whether the project will meet its success factors – typically when the wall and flooring systems have been costed. This 'stop/go' decision will be informed by a preliminary estimate of the square metre construction rate.
- 3. The lateral and vertical alignment of walls, if possible, to reduce eccentric loading of beams and other structural elements.
- 4. Creating visual interest through set-backs and projections of the facade.
- 5. Achieving standard dimensions of bedroom and bathroom layouts to minimise construction errors.
- 6. Ensuring the most sensible configuration of parking bays and vehicular access to maximise site efficiency (where at-grade car parking is provided).

Benefits:

Renewal SA experienced the following benefits for the demonstration project by undertaking the above actions:

- The most efficient design from a construction cost perspective
- Confirmation of the most appropriate materials for construction from a cost, durability and aesthetics perspective
- Minimisation of material wastage and cost by reducing onsite construction and labour times
- Highly efficient integration of building services with reduced pipe runs
- Lower building lifecycle costs for building owners and tenants.

Key Lesson

Start and continue with an open mind always reviewing options and the design for building efficiency and savings.

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G. Interim Stop / Go Assessment

The purpose of the interim stop/go assessment is for the project team to critically address the following question: are we on the right track to meet our success factors?

This question is much broader than simply meeting the target construction square metre rate: it also captures the overall viability and marketability of the project. Importantly, even at this stage of the design documentation process, it is still not too late to make significant changes in core elements such as wall and flooring system selection.

As part of the value engineering process to deliver a market-responsive and commercially repeatable building, selection of the appropriate level and standard of internal finishes and appliances are also critical.

Actions

Renewal SA undertook the following actions, to inform a 'stop/go' assessment, as part of the demonstration project:

- Thoroughly investigating the project's marketability by such actions as seeking market feedback from selling agents on retail price points and comparing features of similar development.
- 2. Continually cross-checking each element of the project against the previously-determined success factors.

- 3. Careful selection of an appropriate level of finishes to ensure a market-responsive design
- 4. Regular assessment of the proposed construction methodology and materials selection against the target construction square metre rate.
- 5. Ensure any financial calculations take into account the impact of GST.

Benefits

Renewal SA experienced the following benefits for the demonstration project by undertaking the above actions:

- To give confidence in making a decisions to proceed with the project in its current configuration, or whether it needs to be modified or even abandoned.
- To provide confirmation of the project's commercial viability.
- The end product is of an appropriate standard for the target market.
- To achieve the project success factors.

Key lesson

Make sure the design and costs are absolutely aligned to the project objectives and is market responsive.



H. Validating the design concept

Having determined that the project will proceed following the interim stop/go step, the final stage is to complete full documentation and tendering of the construction-ready design. This is typically the most time-consuming and labour-intensive part of the entire design process.

In the case of the apartment demonstration project, Mossop continued to liaise and investigate opportunities with potential suppliers to find additional cost savings in the preferred design and construction methodology. Once documents were completed by the design team, the builder tendered out to and received over a 100 trade packages to verify that the target square metre rate would be achieved. Throughout this process, the design was adjusted to remove superfluous items without compromising on aesthetic appeal and market requirements, or structural integrity, or affecting planning approval.

A key learning for the project team was to resist the temptation to be reliant on any one product, it is important to remain flexible in thinking so as to be able to substitute a particular product (or system) with another of similar and potentially better performance characteristics and cost benefits.

Actions

To ensure the design concept was validated, Renewal SA undertook the following actions as part of the demonstration project:

- 1. The design team was commissioned to produce fully detailed design documentation including all drawings and specifications.
- 2. There was collaboration with the builder to ensure key finishes and equipment selections and all other building elements were consistent in quality and quantity with previous budget estimates.
- 3. Conducted an adequate tender process to encourage competition among suppliers to deliver the best price.

Benefits

Renewal SA experienced the following benefits for the demonstration project by undertaking the above actions:

- Ability to meet the target construction square metre rate and other success factors
- Maximises design quality
- Serves as a final stop/go assessment prior to construction.

Key Lesson

Even late in the design and tendering process, be willing to substitute a particular product with another of similar or better performance characteristics.

"PROVIDE AN OPTIMUM TURN-KEY PACKAGE FOR RESIDENTS WITH STRATEGIES TO PROVIDE A HIGH DEGREE OF DAY-TO-DAY AMENITY COUPLED WITH 'HIP POCKET' CONSIDERATIONS"

PART B – CASE STUDY

Introduction

The Case Study forms part of the suite of documents detailing the Apartment Construction Cost Demonstration project which include The Research Report Summary and Part A - Lessons Learned.

This Case Study covers the following topics:

- 1. The brief, the turnkey objectives and market responsiveness of the design
- 2. The process of materials and construction systems research
- 3. The iterative design process undertaken
- 4. The process of select preferred construction systems and comparing costs based on rates and a value engineering approach
- 5. Comparison of the final eight options including market testing on tendered documentation and preliminary costed options
- 6. A discussion on the statutory, building servicing and building management considerations as part of the decisions forming the final design
- 7. Conclusion

The brief

The brief called for a 'turn-key' apartment building providing 20 apartments of four storeys, offering housing variety and market appeal. The four storey height was nominated by the Industry Reference Group as it fits within the relevant Woodville West development plan and is a height that involves financial, BCA and construction challenges that lower scale buildings would not. As such, the nominated building height of four storeys was seen as being better suited to the objectives of the demonstration project than a three-storey development.

The design team responded with a 20-apartment four-storey building offering a range of accommodation with at-grade parking and storage spaces.

Under-croft and part under-croft car parking options were considered.

Underbuilding car parking establishes two grids; the car park grid and an apartment grid that do not coincide. Transfer slabs and/ or beams incur costs that are not required with the direct load path model. On the basis of the construction costs versus land value, the underbuilding or part underbuilding car parking was not adopted as the at-grade car parking provided the optimal financial performance for the project.

The market brief for product mix of one and two bedroom apartments (with study variants) has been achieved. The efficient uses of space have been the key drivers and have resulted in functional and liveable apartments with pleasant spatial flows, yet on or below the briefed areas.

Туре	Floor areas (excl. balconies) m ²	Balcony areas m ²	Quantity	Apartment / bedroom mix	Indicative retail pricing
1 bed	54.2	12	2	10%	From \$265,000
1 bed + study	69.7	12	2	10%	\$310,000 - \$320,00
2 bed	64.2 to 70.26	12	12	40%	\$315,000 -\$330,000
2 bed + study	69.7 to 71.6	12	4	40%	\$325,000-\$342,000
Total			20	100%	-

Table 2: Product mix & pricing

The turn key objectives

Aiming to provide an 'affordable product,' should not translate into the building being 'cheap.' The team's aim was to provide an optimum turn-key package for residents with strategies to provide a high degree of day-to-day amenity coupled with 'hip pocket' considerations.

To create appeal, the points of difference include the following consideration:

- 1. The architecture whilst stylish has durable long life-cycle finishes specified to minimise ongoing cost impacts on the corporation's 'sinking fund'.
- 2. The architectural design considers function, spatial efficiency and visual flows to enhance each apartments 'feel' and scale.
- 3. The building fabric contains 'mass' that translates into positive thermal and acoustic properties.
- 4. Lowered living costs due to environmentally-sustainable design features such as solar access, good cross ventilation, high level of thermal performance and durable materials (requiring less maintenance costs).
- 5. Provide a pleasant entry and one with (preferably) some outlook or exposure to an interesting room; avoid looking into toilets or laundry spaces.
- 6. To provide apartments with a market value proposition that translates into efficient, useful, liveable spaces and good-sized rooms and avoids long (wasteful) corridor spaces.

- 7. Balconies as an extension of the living areas providing a useful space with the capacity to be an outdoor room.
- 8. Aesthetically pleasing, quality appliances, interior fixtures, fittings and finishes.
- 9. An appliance provision and specification to exceed expectations beyond the price point.
- 10. Strategies to minimise energy use have incorporated to benefit the end user.
- 11. Step level entries.
- 12. Crime prevention through environmental design (CPTED) principles at work with passive surveillance, intercom-operated main entry doors.
- 13. Effective cross ventilation is enabled through design considerations.
- 14. Efficient and effective air-conditioning is specified.
- 15. All bedrooms to have access to natural light and ventilation. Ceiling fans have been specified for each bedroom.
- 16. Apartments are NBN ready.
- 17. Lighting levels have been designed for functional output with quality LED lighting fittings.
- 18. Each apartment comes with undercover parking (car ports).

The end result delivers on the promise of above and beyond the 'typical' offering.



THE APARTMENT CONSTRUCTION COST DEMONSTRATION PROJECTRESEARCH REPORTNOVEMBER 2016



Marketability

For affordable housing solutions to be successful, the design needs be tailored to market demand and expectation. To test the assumptions of the design team, marketing advisors were consulted and provided feedback on the design and market expectation. The feedback and comments have been integrated into the design.

For reference, the demonstration project bases 'Affordable Housing Price Points' on the State Government Affordable Homes Program guidelines – see appendix for more detail.



Research and Design: The Process not the Solution

Rather than assume a solution based on default experiences, the derived answers are the product of an exploration exercise and the attitude of the project team partners. This response acknowledges and addresses the importance of the impact of site variables on a project. Site location and configuration influences site efficiency and the area of land necessary; council development plan building heights and boundary offset controls; the proximity of a significant tree (even though on an adjoining site) could impact on land use; water flows and pressure impact on fire management and may drive the selection of construction types.

This case study aims to demonstrate the variables that impacted on the demonstration site and outlines the responses to those forces.

The key outcomes and lessons learned are from the process and the assessment of each item, resulting in selections based on strengths and avoiding the obvious trends or myths.

For example for the demonstration project, the project team found that:

- 'CLT offers phenomenal properties and is lightweight and quickly erected' - yet under examination it was found for the demonstration project to be not suited to a building of this relatively small scale, whereas every day lightweight timber framing has the potential for a cost effective solution. (The suppler of CLT advised the design team that it becomes cost effective in higher rising buildings of 70 to 80 apartments).
- 'Precast concrete is too expensive' yet we found the market condition during the research phase such that precast was being delivered at exceptionally good and cost effective rates.

In this highly collaborative process, the partners' best strengths and knowledge were used to review and assess the options in a series of workshops, deriving possible solutions from first principles.

System and technology investigations

The research and design phase saw the exploration of numerous new building systems and technologies. Renewal SA, Mossop and Studio Nine gathered data on systems and conducted information sharing workshops.

Materials Matrix Sheet

As part of its research process for the demonstration project, Studio Nine established the materials matrix spreadsheet of new and/or materials of interest as an internal working document, capturing information under functional headings such as wall materials, floor materials/systems, claddings and other products.

A 'live version' matrix was established for team use throughout the research and presentation phase as it provided a method of capturing continually emerging new systems and materials.

The matrix detailed:

- 1. material description and photographs
- 2. supplementary building materials (fire protection requirements, vapour barriers etc.)
- 3. structural capabilities/ serviceability, optimum spans & durability
- 4. physical properties, (thermal properties, fire resistance, acoustic attenuation, vapour permeability etc.)
- 5. supply chain (country of origin and point of supply)
- on site management (lifting equipment, speed of erection, fixing techniques, trade skills)
- 7. perceived services implications
- 8. indicative (relative) costs.

Site visits

Following the initial desktop and workshop evaluations (assessing benefits including value and technical properties), the team compiled an invitation list of industry suppliers to present their products. In collaboration with Mossop, the materials and systems were short listed by Studio Nine and suppliers were invited to present in sessions which were held throughout the research phase. The material matrix continued its evolution during the rounds of presentations and supply of documentation.

Studio Nine began basic schematics towards the end of the presentation series to determine site constraints on building proportions as well as considering logical layouts and assessing the symbiotic benefits and opportunities of the various materials and systems.

In collaboration with the project team, the schematics were examined and refined in an iterative manner in accordance with the key objectives outlined in the design methodology and against the target construction rate.

Construction techniques and material assessments

For the demonstration project, the construction techniques/ material assessments included:

- Exploring not only the strengths, but also the weaknesses such as the time and materiality required in lightweight timber framing of connection techniques to achieve rigid and fire resistant joints (where failure usually begins).
- 2. Imagining innovative design is possible by using every day readily available materials.
- Determining the range of additional materials or systems required for technical performance to be achieved and their impact upon construction programs and budgets.
- 4. Integration and combination of both domestic and commercial construction techniques for construction simplicity and economic benefit.
- 5. Creating pods and/or building item replication for economy and with minimal structural change, providing each with character.
- Not automatically assuming that one structural / construction system is superior to another, as all buildings have differing objectives and site constraints, as do the strengths and preferences of individual contractors. An understanding of these factors is required for clear assessment.
- 7. Assessing the market appeal including streetscape contribution, identity, spatial and volumetric dynamics.

We found that for the purposes of undertaking the demonstration project, when assessing the properties of innovative materials and systems, it was important to understand that they can often require an alternative solution assessment (under BCA) that amplifies the above considerations. Our assessment factored in on-site skill requirements, cost implications of specialist professional and/or trade knowledge, professional fees needed to manage an alternative approvals process, as well as the time delays and holding costs of extended approval timelines and the impact on the construction times and preliminaries.

The elements of success lie in starting with and maintaining an open mind and thinking through the various options – simple approaches can often be overlooked.

Cost Variables

The cost variables identified included:

- time on site
- modulation/standardisation to assist trade certainty to minimise delay due to error
- off-site time gains with prefabrication
- simplification of form and structure
- acknowledging the key strategic alliance between builder and supplier.

Other key considerations

Other key considerations included:

- rise to the challenge of providing a durable, cost effective and innovative solution.
- actively looking outside the team's comfort zone of tried and tested solutions by seeking innovative answers worthy of a demonstration project.
- assessing market forces on materials as often material costs are driven (up) by demand. The aim was to avoid a high cycle, yet provide a building solution fluid enough to adapt to changing market forces.
- lowering life cycle costs by balancing cost and durability to deliver a building requiring the least financial and materialintensive maintenance program to residents.
- having the ability to substitute materials and/or systems to avoid the vulnerability of being 'locked in' in cases of nonperformance, bankruptcy, increased workload due to demand etc.

Cost Reduction Approach

Throughout this phase of the demonstration project, effort was focussed around the following four broad themes:

Design

- Innovative: clever layout and use of space, orientation benefits
- Sustainable: reduce material/energy demand and requirement
- Constructability: ease of construction, assembly, interfacing
- Replicable: modular concepts, readily available technology.

Cost

- Cost centres: identify high impact cost centres, market test options
- Modular: ease of measurement, use of materials, less waste
- Materials: check a wide range of options, ease of use, durable
- Labour: less on-site labour and manual handling, safety
- Time effective: reduced on-site activities, less prelims, less hire.

Program:

- Off-site works: maximise off site fabrication, storage, assembly time
- Prelims: less time on-site reduces prelims, supervision, hire charges for plant and utilities
- Labour: reduced labour on site reduces utilities, consumables injury chances and safety provisions
- Equipment hire: clever packaging and scheduling may reduce plant and equipment hire periods.

Operational efficiency:

- Less operational costs: selection of technology to suit both construction efficiency and to reduce ongoing demand on energy.
- Less maintenance: selection of materials that reduces need for periodic maintenance and upkeep.
- Durable: good quality materials and fixtures that has long life and does not require frequent replacing.

Cost Centres

Based on the building partner's previous experiences in similar projects, a cost centre was established detailing the percentage each building element is of total construction cost. The identification of 'big ticket items' enabled the design team to quickly target areas where it was thought the greatest potential savings could be made. A detailed breakdown list of the buildings cost centres that were identified can be seen in Appendix 7 of this report.

The design process

The building design overlapped the tail end of the research phase and was a natural movement of the collaborative workshops. The schematic proposal is a direct response to the brief and was both driven by and informed the research program.

Design Methodology: The solution approach

The project team adopted the clearly defined strategies and outcomes contained in the New South Wales' State *Environmental Planning Policy 65 – Design Quality of Residential Flat Development (SEPP 65).* Key items relevant to the apartment demonstration project were:

- local context (such as surrounding building form);
- design for resident amenity in the form of access to natural light and cross ventilation;
- passive surveillance with ground floor apartments having direct access to the street as well as a 400mm elevation above ground line to enable passive surveillance of the street yet deliver privacy to ground floor inhabitants.

Diagram 3: typical apartment layouts



Simplification

For the demonstration project, it was found that the key element of the design process has resulted in a process of simplification to arrive at:

- 1. Efficient, simple floor plans eliminating nooks and crannies or wasted space within a tight envelope that minimises building area.
- 2. Building is stacked for the structural simplicity of vertical load transfer and services.
- 3. Apartment layouts and arrangements where in acoustic transfers between areas is managed through location rather than the use of materials.
- 4. Circulation/ corridor spaces being functional, semi-enclosed spaces to minimise areas and the materials used.



Standardisation

For the demonstration project, it was found that modularised/ standardised design facilitates trade certainty and eliminates wastage through error. More poignantly, this facilitates the emerging potential for off-site pre-fabrication, minimises on-site times, the reduction of site risk and accidents, and the reduction of neighbourhood congestion. This has resulted in:

- 1. all bedrooms having the same foot print
- 2. all bathroom and laundry combinations being the same with consideration of locally-sourced factory construction
- 3. living areas being the same dimension
- 4. co-location of bathrooms, laundries and kitchens to facilitate simple efficient riser locations
- 5. kitchen configurations being the same.

Sustainability

To improve sustainability, building materials were selected not only on a value-formoney basis but also durability to minimise maintenance costs to the body corporate (ultimately residents over the life of the building).

The building has been designed to achieve a 6-star energy rating based on NatHERS (The Nationwide House Energy Rating Scheme).

Solar orientation and cross ventilation were addressed in the following manner:

- window and deck orientation for four of the five north-facing living area windows and/or outdoor living areas.
- open circulation spaces to provide for cross-ventilation.
- security screen doors on apartments to assist cross ventilation (optional installation only).

De-materialisation strategy

As part of the design process for the demonstration project, reducing material layers was adopted as a way of reducing construction costs. This 'de-materialisation' strategy comprised:

- adopting a 'squarish' building form to minimise the extent of external walls (other than a sphere, a cube is the most efficient building container);
- avoiding indentations (for articulation) to reduce building material and building complexity;
- using materials that do not require coatings (and subsequent re-coating) such as off-form concrete and galvanised steel;
- ensuring that integral parts of the building (such as walls) are the load bearing elements to avoid secondary framing;
- incorporating continuous and minimised spans to provide a wider choice of materials as well as efficient and effective usage;
- minimising the material required to manage sound transfer by co-locating kitchens and bathrooms; and
- designing partially open semi-public spaces.

Recycled materials were incorporated to reduce the building's resource and carbon footprint. Materials include recycled timber and a reusable plastic formwork manufactured from recycled materials, and other ICF reform proposed for lift shafts and stairwells.

Industry experience shows that about 30% of building materials become waste due to overordering and on-site error. To reduce waste, modularised/ standardised apartment layouts were adopted, as it:

- simplifies take-offs, material ordering etc. to reduce over-ordering;
- minimises the chance for error, material waste and on-site times;
- reduces waste in areas such as carpet sizing by having room designs based on material modules.



Visual 10: developing sustainable outcomes

Social Sustainability

Amenity issues include:

- identity ("that is my apartment there") has impact on built form;
- thresholds signifying the interface of public to semi-private (of the entry experience).
 When entering the building, the common spaces are transparent, paths are easily navigated and people feel safe. Those spaces will be treated like undercover verandas;
- the semi-private to private door way providing identity for each apartment;
- then into the private spaces on entering apartments, visitors are presented with a borrowed view through a window beyond, not a toilet door; and
- apartments being raised to afford privacy from the street, yet living areas are provided with a clear view of the public realm.

Place making, wherein encounter points have been considered:

- the letter box;
- the circulation spaces and the potential for occasional seating; and
- bike hanging spaces for residents in the circulation space/ foyer areas.

Other social strategies include the option for each apartment to be fitted with a screen door (for ventilation) and for residents to hear what is happening in the semi-public spaces to:

- promote a sense of community awareness;
- improve safety arising out of the passive (audile) surveillance of the semi-private spaces.

Confirming a preliminary design concept

As part of the research and design documentation phase for the demonstration project, the preliminary design was set and agreed. Using this design as a basis to snapshot the gross building area, building heights, and site requirements then enabled the Mossop to initiate preliminary cost estimates.

Shortlisting construction options

For the demonstration project, we have established the research of materials and systems process, including materials matrix, workshops and preliminary concept designing. In some instances to better understand the product offerings, site visits were undertaken to prefabrication plants or to see materials in use. A summary of site visits and workshops are evident in Appendix 10. To round out the selection process, Mossop undertook the costing of the most appropriate materials and techniques.

Iterative process and value engineering

The combination of materials and construction systems investigated in light of the project objectives required the builder to eventually 'select' a number of key elements to commence initial estimates. As with the design being improved over a number of iterations of refinement, the process of the ultimate option also required a series of attempts and was dependent on market forces in as much as any pure innovation yielding a stand-out in cost savings.

Superstructure construction - walls and floors

Led by Mossop's, the point of focus for the project team of consultants for the preliminary costing was walls and flooring (the superstructure). This framework of the building making up a significant proportion of total cost (typically 30% in a multi-storey apartment building).

Walls

For the demonstration project the following elements are examples of systems compared to derive the costed options and included possible increases for offloading and installation and fireproofing:

- Insulated concrete form, permanent polymer formwork (concrete infill formwork products);
- Lightweight sandwich panels (fibre cement sheet and steel stud frames core filled with concrete);
- Pre-cast concrete;
- Various forms of manufactured dry-wall sheeting (such as compressed fibre cement sheet products) and Autoclaved Aerated Concrete (AAC) wall types;

- Recycled industrial waste based masonry;
- Engineered wood systems, such as Cross Laminated Timber (CLT);
- Structural Insulated Panels (SIPS) technology.

The square metre rates of these items were compared including dependence of the following additional cost considerations:

- Internal plasterboard lining;
- External finishes render and/or paint;
- Steel cast in plates for support;
- Scaffold and edge protection requirements;
- Internal wall insulation / acoustics.

Mossop worked in conjunction with the structural engineer and across the design team consultants as a whole to review the issues associated with each system, weighing up cost and design functions.

Floors

For the demonstration project, the following elements are examples of the systems compared to derive the costed options and included possible increases for offloading and installation and fire proofing:

- Traditional in-situ reinforced suspended slab;
- Post tensioned reinforced concrete slab;
- Precast concrete beam system coupled with steel formwork and in-situ slab;
- Hollow core precast concrete slabs or planking with topping;
- A reduced weight concrete floor system comprising of a thin precast concrete panel with a void forming layer of reinforcing and hollow plastic balls and topped on site;
- Hybrid suspended flooring with steel joists and thin slab;
- Engineered lightweight cassette system using a composite timber flanged and steel webbed joist, engineered sheet flooring and fire rated linings;
- Reinforced autoclaved aerated concrete panels;
- Engineered sheet flooring over framing joists being either LVL or a composite timber flanged and steel webbed.

The square metre rates of these items were also compared including dependence of the following additional cost considerations:

 Concrete supply, reo supply, crane hire (lift reo), concrete labour, and concrete pump.

Similarly, the builder partner worked with the structural engineer and architect to review the issues associated with each system. Such considerations centred around wall thicknesses, load, span, and fire rating level achieved, and constructability.

Commitment to detailed design

For the demonstration project, using the preliminary concept design, the learnings of the materials research and above systems pricing, Mossop was able to compare various construction options to building the 4 storey apartment building. This process allowed the project team to determine if the design and project was on track to meet the target construction rate. In addition, updated market appraisals were undertaken to assess the apartment prices.

An important juncture was to ensure two things: the target construction square metre rate could be achieved and the apartment pricing was in line with the forecasts. On completion of this preliminary feasibility based on this 'stop / go' approach, the project could then move into the full detailed design documentation, undertaken by Studio Nine. This process helps to validate the commercial viability of the project.

The full documentation phase brought together all the marketing, services and building management and construction research to ensure "the right design for the right price". This was ultimately tested when Mossop tendered the building. The tender, managed wholly by Mossop, sought prices from over 100 trades across the different disciplines. As a matter of course, suppliers pricing may be subject to change over time, and the estimation of quantities from a preliminary design to a detailed design can and did influence the final cost.

On this project, a number of factors affected the preliminary cost per square metre rate on having moved from the preliminary concepts to full documentation design. This required a systematic review of the design and building specification. Issues arising were as follows:

- Nominal increase in the gross building area as a result of transitioning from concept to detailed design for the basis of estimation of costs.
- Changes to pricing from the preliminary concepts to final tender pricing, requiring the substitution of product selection for major structural elements;
- Architectural and engineering selections of finishes, products and equipment, such as:
 - deletion of louvre and posts from balconies;
 - internal stud wall replaced with structurally insulated panels (SIPs);
 - balustrading change from glass to perforated aluminium;
 - deletion of screen doors from standard design;
 - sanitary ware changes;
 - lift equipment size changed;
 - scaffolding adjustments;
 - amended external fencing construction including bin enclosure from brick and insulated concrete form to a metal sheet fence (and paint finish);
 - removed bored piers for perimeter fence and replaced with concrete retaining wall.

These proposed changes resulted in real savings of the final building cost.

This outcome demonstrates the material substitution advantages in not being locked in to any one product, thereby easily substituting a material with minimal impact on documentation. This is a result of a thorough design process and collaboration between the design and builder teams - a fundamental principle of the apartment demonstration project.

Construction options

Led by Mossop the preferred construction methodology was determined following the evaluation of a wide range of material and construction systems. These were assessed on availability, buildability and cost with more expensive options not considered further.

As part of this process, estimated costs were derived for eight options based on the final design. Using the criteria of availability, buildability and cost, the top three performing options were market tested by Mossop which conducted a tender process based on fully documented drawings and specification. The options are summarised below, beginning with the final preferred option.

It is important to note that depending on market conditions and supplier relationships, pricing can vary. The most cost effective system will depend on the Developer's specific apartment design. For the demonstration project the ability to substitute key selected materials offered the advantage of not being locked in to any one product, allowing for ease of replacing one item for another with minimal impact on documentation.

The Preferred Option

The preferred construction system for the demonstration project as determined by the project team is outlined below. It delivered on key project objectives of buildability and dematerialisation. The details of this system are as follows:

1. Insulated concrete form walling and concrete precast plank flooring.

Rate \$1974 per m² GST inclusive (\$1795 per m² GST exclusive) for the demonstration project and comprising the following:

- External and single occupancy unit (SOU) bounding walls (party and corridor) - an ICF system provided;
 - a load bearing system
 - the necessary fire separation
 - acoustic ratings
- Flooring system a precast concrete system provided;
 - beneficial long spans
 - structural and acoustic properties
 - thinnest slab with a standard ceiling (300mm total depth)
- Internal walls partition style non-load bearing and non-rated.

Buildability

For the demonstration project, the insulated concrete form products tendered to deliver cost savings with flexible composition and corner installation.

This option met many of the de-materialisation strategies in that it delivers the lowest floor to floor height to reduce overall building height; it satisfies BCA fire and acoustic requirements without additional materials; and the proposed external wall system provided the most cost effective outer skin. Diagram 4: Construction planning for tender – ICF layout & section example



Stage 2 - EE270 @3.00m	81.1 M	l
Stage 2 - EE270 @3.15m	71.7 M	
Stage 2 - ER206 @3.15m	5.9 M	
Stage 2 - ER230 @3.15m	8.4 M	
Stage 2 - RR140 @3.15m	2.7 M	
Stage 2 - RR166 @3.15m	3.1 M	

Other options considered

The cost analysis becomes more favourable when the carpark and landscaping costs of the development are excluded from the overall building cost, reducing the rate to \$1870 per m² (GST inclusive) or \$1700 per m² (GST exclusive) for the demonstration project:

These two options were also market tested, based on fully documented designs:

2. Insulation Concrete Form walling and concrete precast plank flooring (same as option 1 but using alternative products). Rate was \$1985 per m² GST inclusive (\$1805 per m² GST exclusive) for the demonstration project, and comprised the following:

 external and SOU bounding (party and corridor) walls – ICF load; bearing and requiring no additional acoustic treatment;



- flooring system a precast concrete cassette system;
- thinnest slab with a standard ceiling (300mm total depth);
- internal walls partition style non-load bearing and non-rated.

Buildability

For the demonstration project, ICF concrete walls and the concrete precast floor cassettes option, as with option 1, was found to meet many of the de-materialisation strategies in that it delivers the lowest floor to floor to reduce overall building height; it satisfies the BCA fire and acoustic requirements without additional materials; and the proposed external wall system provides the most cost effective outer skin.



3. Precast concrete external walls and precast concrete floor cassette system flooring. Rate: \$2028 per m² GST inclusive (\$1845 per m² GST exclusive) for the demonstration project and comprises the following:

- precast concrete external wall frames;
- ICF internal walls;
- pre-cast concrete floor cassette system for the flooring.

Buildability

For the demonstration project, this option was considered as rates offered for this project were far less than those on previous commercial projects due largely in part to the cost effective building detailing.

Normal precast is a durable and efficient construction solution, but to meet BCA part J thermal insulation requirement, an additional inner wall is required for insulating the peripheral walls. This increases on-site time, labour and materials costs (stud walling, insulation and plasterboard). This option used the principle of precast walls and adds an EPS (expanded polystyrene) (or PIR, polyisocyanurate – fire retardant insulation) layer with PVC framing (to act as studs) and window framing as part of the pre-cast. Thus it extends the properties of precast with an added insulation layer and framing to reduce on site work.

It also was found to reduce the need for scaffold and render (as direct paint finish is sufficient), hence the reduced the rate per metre. While the project team was able to design a support frame to accommodate the cassette flooring, the final cost of this option did not bring the total cost under the target construction rate. Another feature of this option focussed on a mainly South Australian based manufactured product.



Diagram 5: Cross section of precast flooring



Visual 12: Concrete floor cassette example

Remaining options (preliminary)

The five remaining options were not market tested. A preliminary cost estimate based primarily on floor and walling costs (which typically represent the largest cost centre expense at around 30% of the total building cost) indicated that none of these options were at or below the target construction rate for the demonstration project:

4. Precast concrete, ICF party walls and concrete plank flooring.

Rate \$2006 per m² (GST inclusive, based on preliminary concepts only) for the demonstration project, and made-up of the following composition:

- external walls precast concrete load bearing external walls with paint or render finish, with an internal insulated skin to achieve thermal compliance;
- single occupancy unit (SOU) bounding walls - ICF load bearing and requiring no additional acoustic treatment;
- flooring a precast pretension plank floor system long span;
- internal walls partition style non-load bearing and unrated.

Buildability

For the demonstration project the upward cost pressures for this construction technique are the treatment of the external walls and the insulated skin.

5. Hybrid 1 - heavy weight base with lightweight upper levels.

Rate \$2059 per m² (GST inclusive, based on preliminary concepts only) for the demonstration project, and made-up of the following composition:

- ground floor load bearing ICF wall system and a pretension precast; concrete plank system floor system;
- upper levels timber framed flooring and walls;
- fire rated ceilings;
- sprinklers protection required.

Buildability

For the demonstration project this option delivers some cost effective outcomes such as a building with lesser weight and reduced footings, yet the requirements for sprinklers and timber framing detailing (charring blocking for fire protection etc.) pushes out construction costs. The review session found the following issues additional on-site time, additional materialisation and subsequent construction cost, ongoing maintenance and system auditing costs.



Visual 13: Example of construction planning for estimation of preliminary costings

6. Hybrid 2 - ICF & lightweight timber.

Rate \$2060 per m² (GST inclusive, based on preliminary concepts only) for the demonstration project, and made-up of the following composition:

- external walls timer framed, load bearing and rated, cladding required
- single occupancy unit (SOU) bounding walls – ICF load bearing and requiring no additional acoustic treatment;
- internal walls timber framed fire rated and loadbearing internal walls.
- sprinklers required to meet deemed to satisfy criteria of BCA;
- floor system a cassette floor system requiring fire rating and acoustic treatment.

Buildability

For the demonstration project the cost pressures of this system are the 2 layer ceiling system to create the void for services and external skin cladding including sarking etc. with floor/ ceiling depth of 420mm which increase building height.

7. Traditional heavy weight & suspended slab.

Rate \$2267 per m² (GST inclusive, based on preliminary concepts only) for the demonstration project, and made-up of the following composition:

- external walls precast concrete, with an internal insulated skin to achieve thermal compliance;
- sou bounding walls ICF load bearing and requiring no additional acoustic treatment;
- flooring system traditional structural steel decking no internal load bearing walls;
- internal walls partition style non load bearing and unrated.

Buildability

For the demonstration project, the upward cost pressures for this construction technique are as follows:

- heavy weight construction requires increased footing sizes/ costs;
- the precast wall requires an internal insulated skin to achieve thermal compliance;
- a slower construction system (propped floors etc.) increases the 'preliminaries.'

8. The masonry veneer solution.

Rate \$2344 per m² (GST inclusive, based on preliminary concepts only) for the demonstration project, and made-up of the following composition:

- brick veneer with structural steel framing, suspended concrete flooring, precast stairwell/ lift shaft;
- external walls a concrete brick or block external wall with an internal timber framed insulated skin to achieve thermal compliance;
- load bearing structure steel framed columns and beams;
- single occupancy unit bounding walls ICF load bearing requiring no additional fire protection or acoustic treatment;
- timber framed internal occupancy unit (IOU) walls non load-bearing.

Buildability

For the demonstration project, the upward cost pressures for this construction technique are:

- the work flow impact of the slow brick/ block laying process.
- fire protection of the steelwork;
- a slower construction system (propped floors etc.) increases the 'preliminaries';
- construction methodology.

Prefabricated bathroom pods

During the design process, concurrent investigations continued into alternative and innovative methods of delivery. In particular prefabricated bathroom pods were taken into account and costed and compared to the traditional wet trades laid in situ.

For the demonstration project, factors that affected this innovation not being adopted are as follows:

- found not to be cost advantageous (against traditional trade approach);
- found to have issues with fire integrity and penetrations of single occupancy units (of services and pipework);
- confronted issues of accessibility levels (step up into the bathroom pod); and
- found to have an increased material use (double up of floors on floors).

Accessible apartment

The final concept allows for an accessible apartment which speaks to the high level of design innovation embodied in the project. It demonstrates the flexibility of the design by the conversion potential of apartment 4 on the ground floor. This is an example of the universal nature of the design, its modularisation and uniform room sizing. It is the openness of the floor plan and the generous sizing of rooms that contribute to the ease of conversion. The extract below of the building floor plate depicts this optional feature, requiring only internal modifications.





Diagram 6: Apartment 4, ground floor – Accessible option

Method of measurements

For benchmarking purposes, floor space measurement was calculated in accordance with the Property Council's *Method of Measurement for Residential Properties* (Section 2: Apartments and Sole-Occupancy Units).

Assessment metrics

During the assessment of design and costs phase an interesting discussion emerged within the project team. Whilst a lot of emphasis was placed on a target construction rate per square metre, caution is required when referring to generic rates as this could lead to potentially misleading conclusions.

The final design of the apartment demonstration project provides a 'dollar dense' building as the efficient solution proposed by Studio Nine & Mossop has minimised areas. Such buildings include 'high cost areas' (the apartments) and 'low cost' areas (e.g. plazas, large balconies, grand 'public' / common spaces, and car parking). When 'low cost' construction areas are incorporated within the overall building area, the resultant rate per square metre reduces. However, by creating efficiencies and especially when reducing the proportion of 'low cost : high cost' areas, counter intuitively, the rate per square metre increases. An example of this can be seen below.

Analysis by the project team for the 4-storey apartment demonstration project building at The Square in Woodville West had the following parameters and notable net result:

- total area (apartments only): 1985 m² (Gross Building Area)
- no. of apartments: 20
- cost of construction:
 \$3,918,390 (inclusive of GST)
- rate per m²: \$1974 per m² (inclusive of GST)
- cost per apartment:
 \$195,920 (inclusive of GST)

When compared to a similar project within 5km of the CBD that is only 3 storeys with undercroft car parking we find the following net result:

- total area (apartments only):
 2502 m² (Gross Building Area, GBA)
- no. of apartments: 16
- cost of construction:
 \$4,500,000 (inclusive of GST)
- rate per m²: \$1798 per m² (inclusive of GST)
- cost per apartment: \$281,250 (inclusive of GST)

Whilst the second example appears to be the more cost effective outcome it is not the most accurate determination of construction cost. The apartments demonstrated at The Square indicates that they are \$85,243 less per apartment (including carpark) to construct. This outcome demonstrates the construction cost reduction is achieved through efficient construction techniques (load direct to ground enabled by at grade parking) coupled with efficient spatial design, even though it is a four storey building which automatically triggers higher construction costs (due to lifting equipment and site preliminaries).

Another way of looking at these metrics are by examining the construction rate to include the car parking areas (whether within the building envelope or at grade), and in the case of the final demonstration apartment design, we find as follows:

- total area:
 2568m² (GBA + at-grade carpark area)
- no. of apartments: 20
- cost of construction:
 \$3,918,390 (inclusive of GST)
- rate per m²: \$1528 per m² (inclusive of GST)
- cost per apartment:
 \$195,920 (inclusive of GST)

Statutory requirements

For the demonstration project, the project team had to consider the following statutory requirements for the design, materials selection and construction methodology of the four-storey apartment building.

Development Plan

The subject site is within the Woodville West Policy Area 23 and adjoins the Core Precinct. The objectives, desired character and the principles of development control of the development plan provided design cues and played a significant role in shaping the project, from overall urban form and character, to building heights, setbacks, privacy screenings and treatments and passive surveillance considerations.

To realise an affordable apartment building replicable in a number of locations, the 'approvals process' should be typical. The project aimed to design within requirements of the Development Plan and not push boundaries.

Building Code of Australia

The four storey Class 2 with Type A construction requirement challenges cost effective construction and methodology. Key BCA considerations for the demonstration project included:

- a. the maximisation of apartments utilising the core, minimising circulation and achieving egress distances play a significant role in the building layout and overall reduction of area.
- b. accessibility
- c. opinions were sought from the consultant design team to review material properties, provide spatial analysis and comment on fire stability and amenity components of the BCA.

Land Prerequisites

Site constraints and opportunities

The subject site is located on Sweeney Terrace, Woodville West, with open space and the core precinct to the immediate north and in close proximity to bus and rail links.

A site constraint having impact on the development was land value: the higher the cost of the land, the more undercroft parking becomes economically viable. Conversely, low value land will not economically support the higher construction costs of undercroft parking (evident in the project site).

Located on the intersection of Sweeney Terrace and a proposed lane (to the western edge), the site had two frontages. The bus and rail stops are a short walk along Sweeney Terrace.

The two frontages provide the opportunity for pedestrian access to the 'front door' facing Sweeney Terrace and a service and vehicular access is off the proposed lane.



Visual 14: Locality plan

This opportunity enables:

- vehicular and pedestrian separation to provide a safe and pleasant point of arrival;
- b. a pedestrian access point from the core precinct and rail station link;
- c. discreet services and waste collection point accessible from the street and lane;
- spatial and economic advantages the two frontages eliminated the land use and costs given over to vehicle circulation (such as long driveways and paving);
- e. efficiency of the building shape/ envelope and vehicular circulation and in turn the feasibility of a project due to the regularity and proportion of the site.

Regulated Trees:

Having no regulated trees on the site or adjoining sites delivered efficiencies, in that root protection curtilages did not impact on the land use. Whilst there are a number of trees in the general area, on the advice of an arborist, they have been declared poor specimens with structural deficiencies or disease and, being so, will be removed if construction commences on site.

Proportions and car parking

Car parking is located on the rear portion of the site with direct access from a lane which provided circulation efficiency. Through efficient building design and site layout all building, car parking, storage, access and services requirements were accommodated on the site of 1390m².

Social impact

Neighbouring zones: The physical and psychological connections to local facilities (shopping, sporting organisations) - as well as walking distances/ patterns and the proximity of public transport - were all key factors recognised during the design process.

The Woodville West Concept Plan indicates the precinct as a medium density neighbourhood, a rise in scale from 2 storey (immediately adjoining the lower density residential lots to the south) rising to 3, 4 and 5 stories (in the core precinct to the immediate north). Given the subject site is located on the cusp of the 4 to 5 storey rise, it would appear to have little neighbouring zone impact.



Diagram 7: site plan including proposed landscaping.

The building is designed for CPTED principles and contributes to the neighbourhood's social amenity in the following manner:

- a. providing passive surveillance of the street from the apartments
- b. ground floor apartments with direct access to the street
- c. the apartment building's front door is located off the transport infrastructure linkage.



Visual 15: View from the site looking north-west

Services Infrastructure, and Utility Management

Services and infrastructure are paramount with any feasibility as the investigation of existing water pressure and flows, electrical capacity, sewer capacity, and gas capacity will impact upon system decisions and construction costs. For the demonstration project, the following solutions are based on testing data, cost-benefit analysis of services and metering costs provided by Secon Consulting Engineers (see Appendix 9 for full report).

Deliberate decisions are required based on how the building will be managed. This provides a further opportunity for cost savings on capital and operational expenditure that impacts on the cost per square metre rate for construction and ultimately affects the affordability of living in the building for the future occupants.

a) Electrical

Electric / induction hotplate

The team decided to specify an electric / induction hotplate in the kitchen in lieu of the more traditional gas stove, as it saves on additional infrastructure costs of having a separate series of pipework required by gas.

Photovoltaics (PV):

Careful consideration of PV's on the roof warranted an appropriate cost impost review of who pays and who benefits. Currently the most effective use of photo voltaic cells is at the time of generation. This is envisaged to be while the majority of residents are predominately away from the premises (at work). There will not be any real economic advantage with a 10 year return on investment. Battery technology and reducing capital cost indicate storage systems are on the cusp of being a viable alternative to energy supply.

Subsequently, the project team excluded the use of photovoltaic systems as there was no perceived cost benefit to the residents.

b) Water

The determination of flow rates and pressure should be undertaken at the outset of a project to confirm infrastructure capacity to deliver water for domestic and/ or firefighting purposes as project budgets are influenced by the type of construction or booster systems necessary.

The Woodville West mains water system was upgraded in 2013. However, in Sweeney Terrace, a short section of the existing water main (a 100mm cast iron pipe installed in 1945) was retained as the connection from the project site. Testing revealed that water pressures available at the project site do not meet the demands of domestic potable water for a four storey residential building. As other sites earmarked for 4-5 storey apartments are to be serviced from this section of the existing main, Renewal SA as developer has planned to replace this section of main with an upgraded 150mm pipe as part of the urban renewal works.

If the cast iron pipe was not replaced, a storage tank with dual pressure pumps will be required to boost the water pressure to meet the demands of the potable/ domestic water supply. The replacement of the cast iron section proved to be the most cost effective solution in any event.

Domestic potable water:

Metering options were considered to examine the spatial and pipework requirements to select an efficient and cost effective outcome.

- option 1 individual water meters: 21 retailer meters (20 resident and 1 common) require space on the ground floor and significant lineal metres of pipework.
- option 2 one retail metre: could be supplied with remote reading private meters at each apartment to save on space and pipework costs and managed by the body corporate. However, the matter of delinquent payment will be the responsibility of the body corporate. In keeping with the cost and de-materialisation aim, this option was adopted.

Recycled Water:

in locations where re-cycled water is available, rainwater tanks are not required. As re-cycled water is available and is metered in the same manner as potable water, similarly, it attracts the same metering consideration of individual versus common. In this particular instance, the anticipated low use and resultant negligible 10 cent per day per apartment warranted the use of common meter system. Such costs are added to the body corporate fee.

c) Fire (Services)

Construction Type A (necessary for this type and scale of building) attracts the most stringent level of fire protection. The selection of certain materials for construction may require the fire sprinkler installation to achieve the required Fire Resistant Levels (FRL).



Based on the flow tests organised by the project team with SA Water, a simulation of a combined fire hydrant and sprinkler system of the proposed four storey development was undertaken. Testing identified a large variation in the available water pressure. However, as the water main is being upgraded to a 150mm service any pressure issues would be resolved.

If a lightweight building solution was considered it would require a sprinkler fire protection system with on-going service and maintenance costs borne by the 'Body Corporate.' Should the lightweight solution be a viable option, the decision making process recognised the additional construction costs and the pressures of ongoing cost to the residents' Body Corporate. The alternative was to engineer the building so that fire sprinklers are not required in the form of (heavy weight) construction which would not require sprinkler protection, which at the end of the day proved to be the most cost effective outcome.



Diagram 9: extract of hydraulic services land lord internal reticulation isometric view (services plan – whole building)

Regardless of a sprinkler system being installed, to meet the requirements of the hydrant system (without the need for storage tanks and pumps), the servicing infrastructure would be supported by the upgraded 150mm water main and negate any potential future water pressure issues at the subject site or other surrounding sites developed in the future. In considering construction options for the apartment project as well as considering the standard fire service requirements for the building the estimated costs are presented below: (excluding GST and margins):

- fire tanks and pumps, \$120,000; area, 6m x 11m (assume 144,000l tank, 5.35 dia. tank, 6.5m high)
- mains water tank and booster pumps,
 \$30,000; area, 3m x 5m.

d) Sewer

Drainage

To minimise pipe runs and pipe work efficiency, the building is designed with backto-back risers. Ceiling levels have been set cognisant of the necessary drainage falls.

e) Mechanical ventilation

For safety, roof mounted plant was avoided. Floor by floor location will provide the most efficient, safe access.

Cross ventilation was a significant driver in the apartment building's design. Split system reverse cycle air conditioning would be provided in the living areas with fans in the bedrooms. Bathrooms and laundries located inboard of the building perimeter would have ducted ventilation to atmosphere via dropped ceiling panels (2400mm above floor level).

f) Gas

Gas metering attracts the same responsibility and installation considerations as water and electricity of common versus individual. For the provision of hot water to apartments, the following gas service options were considered:

- 20 individual gas meters provided in centralised locations requires significant free wall space at ground floor level or space at the site boundary and would deliver a poor service with significant 'run-off' volumes.
- Individual gas hot water units located on the balcony of each apartment: was seen as contributing to materialisation, construction and capital cost. Factors included:
 - the exhausting of gas fumes
 - a tundish for each hot water unit, required significant plumbing infrastructure.

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A centralised system was selected because it was considered simple and more reliable. It is available from service providers interested in supplying, installing, managing and maintaining a centralised hot water system (at no cost to the builder, building owner/s or developer). The system includes centralised heating units flued to atmosphere with metered hot water consumption to each apartment and being charged according to consumption.

The user pays for the hot water equipment over time via usage charges. This system rationalises gas metering (managed by the body corporate via issuing sub-metered invoices) and is pipework efficient.

Centralised units are located in cabinets on the top floor in the demonstration apartment building design.

Ownership Structure (Community Titles)

Multi-storey apartment buildings are usually established over a community title. With mixed use such as ground floor commercial or retail, primary and secondary community titling arrangements would be required and early resolution would assist the decision making process relating to services and management. These may impact on project design and cost. However, in the case of a single use building as the demonstration project, it will be established over a Community Title.

The 'Lot' would include:

- the apartment, its balcony and/ or private open space;
- the storage unit;
- the carport.

The 'Common Property' would include:

- the driveway;
- building curtilage (excluding private open spaces for each ground floor apartment);
- refuse area;
- internal circulation spaces including lifts and stairs.

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CONCLUSION

In the case of the demonstration project, the research unearthed a plethora of new materials and emerging systems which are continually emerging. Hence this case study does not propose a single solution to the building cost challenge. Rather, it demonstrates a logical step-by-step process whereby site factors, material selection, construction methodology, influences building layout and design solutions. During our early discussion, an important principle was realised. As a result, we deliberately avoided locking into a one fabricator or one material solution. By allowing such flexibility, it avoids being dependent upon one supplier or fabricator supply path that may cause cost blow outs or construction delays during the building program.

For the purpose of the demonstration project, 'total project construction cost' was defined as the combined cost of site works; at-grade car parking; building services and infrastructure; building cost; landscaping; builder's margin and overheads (including GST but excluding consultants' fees).

Renewal SA was aiming to achieve a total project construction cost between \$1,800 m² and \$2,000 m² (including GST) to ensure a commercially viable development with apartments selling benchmarked during Stage 1 of The Square in the high \$200,000s to low \$300,000s.

The project methodology delivered a marketbased and commercially-replicable fourstorey apartment building at one of the lowest construction costs in Adelaide.

Using the iterative eight-step process outlined in the support documents to this case study (executive summary and lessons learned), the project team achieved a visually appealing and highly marketable design with a construction cost of \$1974 per m² GST inclusive (\$1795 per m² GST exclusive). The opportunity to contribute in the delivery of the Construction Demonstration Project co-operate in a collaborative enterprise was highly rewarding. The success of any project is largely dependent on a few key factors. The team of professional consultants formulated was based on previously demonstrated skills and innovation. This, along with sound methodology and a work structure that streamlines procedures, makes better outcomes easier to attain.

However, this project has an added dimension: the open co-operation and collaboration of the Renewal SA team, the Building Partner and the Design Partners. To this aspect, Studio Nine note they have been proud to contribute to the collaborative and innovative of the Construction Cost Demonstration Project.

APPENDICES

- 1. Key project participants
- 2. Partner profiles
- 3. High level design outcomes
- 4. Affordable housing price points
- 5. IRG participation
- 6. Project schedule
- 7. Cost centres
- 8. Workshops
- 9. Designs

Appendix 1: Key project participants

The Apartment Construction Cost Demonstration Project was made possible through the combined experience and talent of individuals across the public and private sectors.

INDUSTRY REFERENCE GROUP

Australian Institute of Architects: Tony Giannone

Australian Institute of Building Surveyors: Mike Thomas / Tony Travaglione

Housing Industry Association: Stephen Knight

Master Builders Association: Ian Markos / Brendon Corby

Planning Institute of Australia: Rick Hutchins / Rebecca Martin

Property Council of Australia: Anthony Carrocci / Michael Carrocci

Urban Development Institute of Australia: Jim Curnow / Anne Highet

RENEWAL SA PROJECT TEAM

General Managers: Mark Devine & Michael Buchan

Project Sponsors: John Blaess & Vincent Rigter

Project Director: Richard Stranger

Project Manager: Steven Pargaliti

Project Governance: Eric Wisgard

Woodville West Development Manager: Kylee Gligic

Project Marketing: Zara McDonald

BUILDING PARTNER: Mossop Construction + Interiors

Managing Director: Grant Mossop Construction lead: Jathin Balan Construction manager: Tony Leonello

DESIGN PARTNER: ARCHITECTS, Studio Nine

Managing Director: John Galluccio, Design Director: David Ey Architect: Paul Rawinski

DESIGN PARTNERS – CONSULTANTS

Structural and civil Engineers – PT Design Managing Director: Andre Vreugdenburg Structural Engineer: Ronan Whelan Civil Engineer: Matthew Primer

Services Engineers - Secon

Lead Electrical Engineer: Stewart Forster

Lead Mechanical Engineer: Anthony Davidson

Lead Hydraulic and Fire Engineer: Matthew Fetchner

Building Certification – Katnich Dodd

Lead Certifier: Ian Dodd

Fire Engineering – Arup Lead fire engineer: David Graham

REPORT AUTHORS

Editors: Eric Wisgard, Steven Pargaliti (Renewal SA)

Case Study: David Ey, John Galluccio (Studio Nine)

Appendix 2: Partner profiles

Renewal SA

Finding a solution to the current high construction cost of apartment buildings is in direct alignment with the key objective of Renewal SA to provide opportunities for more South Australians to live in homes that are affordable and in areas of their choice.

Pursuant to the Housing and Urban Development (Administrative Arrangements) (Urban Renewal Authority) Regulations 2012, the Urban Renewal Authority (trading as Renewal SA) was established on 1 March 2012 as a statutory corporation reporting to the Minister for Housing and Urban Development with a specific mandate to work on three key State Government priorities – creating a vibrant city, maintaining our safe communities and healthy neighbourhoods and having an affordable place to live for everyone. Renewal SA is a body corporate and is governed by a Board of Management consisting of members appointed by the Governor.

Renewal SA is responsible for planning, managing and facilitating the delivery of strategic residential, mixed use and industrial development projects. With a strong focus on community engagement, Renewal SA works cooperatively with communities, local government, the private sector and the notfor-profit sector to achieve this aim.

All of Renewal SA's residential developments comply with the State Government's mandated requirement for 15% affordable housing - and in many cases, Renewal SA's projects exceed this minimum standard through innovative thinking and diverse housing products.

www.renewalsa.sa.gov.au

Mossop Construction + Interiors

Our business heritage is a unique story of three brothers all with substantial trade backgrounds and experience working for a major builder.

The Mossop name has been continuously associated with the south Australian building industry since 1946 when Bert Mossop did general building work following his return from WWII. In the 1950's he created a niche business building caravans for South Australian families who were increasingly looking for low cost holidays to share with their young families. The '60's credit squeeze put enormous pressure on broadway caravan construction business but again he identified another niche and built a successful ceilings operation.by the late 1970's his three sons, Ray, John and Neil had served their apprenticeships in the building industry as carpenters and joiners and established their own careers in one of Adelaide's largest building companies. In 1979 the brothers established Mossop Group Pty Ltd as a building/interior specialist and the family business has grown to become a significant South Australian based construction and interiors company. Mossop construction + Interiors now based in the iconic church located at 155 Port Road Hindmarsh.

Ray, John and Neil lived by these values gifting a formidable legacy to the firm. They are now entrenched in providing guidance for our everyday behaviour.

- Hardwork: we take pride in our work; we're not afraid of putting in the hours; we go the extra mile.
- Fairness: we achieve the best outcomes for our clients because we are reasonable and respect all people involved in the project.
- Integrity: our word is our bond. We are open, honest and reliable.
- Teamwork: success comes when all members of the project team work together cooperatively and respectfully deal with problems.
- Problem-solving: it is important to anticipate issues and devise practical and intelligent solutions; we exercise care to ensure the best outcomes; "getting it right first time":
- Value for money: we deliver good quality at a fair price.

www.mossop.com.au

Studio Nine

Studio Nine is a multi-award-winning architectural practice based in Kent Town with dozens of successful projects throughout Australia.

The business began in 1998 when three of Adelaide's leading architects came together to collaborate on a project. Each had a different area of individual expertise but all shared one belief: architecture isn't just about buildings; it's also how they interact with people and the world around them. From that single project, the firm expanded over nearly two decades and became Studio Nine, adding a fourth partner in 2007.

Today, Studio Nine has 20 staff members comprising senior and junior architects, interior architects, and technicians working in an open studio environment. This diversity means unique needs can be answered by a tailored expression of architecture, always achieved practically; sustainably and efficiently; whether it's in Adelaide, across the State or across the continent.

The range of work spans the broadest spectrum: apartments; shop-top apartments of three- to four-storeys; medium-density housing; row housing; display/show homes; bespoke one-off houses; beach houses; housing for residents with severe physical or intellectual disabilities; independent living units for the aged; social housing; affordable housing; and short-term serviced accommodation. Education is one of the staples with particular expertise ranging from kindergarten to tertiary facilities. Studio Nine has a great depth of experience in hospitality, including one very famous international chain of family restaurants, restaurants, bars and entertainment venues stimulating and enticing for customers. Commercial ventures have included office buildings, retail outlets and showrooms. Studio Nine has also completed a number of innovative industrial projects as well as retail fit-outs, sporting complexes, urban design projects' (even a mausoleum) and heritage-listed properties.

Past recognition for outstanding work includes the Australian Civic Trust Awards 2014 (People's Choice Award) for Glenunga International High School; UDIA SA Award for Excellence 2013 (Residential Development Award) for Julia Farr Campbelltown; the HIA-CSR Australian Housing Awards 2012 (Australian Display Home of the Year) for "Synergy" and numerous Australian Institute of Architects citations over the years.

www.studionine.net.au

Appendix 3: High Level Design Outcomes

The preferred builder partner is required to assist with the consideration of and respond to the following four principles during Stage 2 (Research and Design Development Phase of the demonstration project:

A. Design

- Attractive and desirable dwellings that provide excellent amenity
- Site and building layout, maximising opportunities for effective use of space, light and ventilation
- Size, orientation and provision of private and communal open space
- Building appearance and visual interest, through use of a range of building materials and articulation in building design
- Appearance and relationship to the street and public spaces
- Response to levels and adjoining allotments, particularly with respect to car parking
- Passive surveillance optimisation for site and building security.

B. Sustainability

- Design of the site and building to reduce resource demands
- Reduced operating costs through wholeof-life consideration
- Selection of efficient appliances
- Water harvest and re-use
- Energy use
- Passive solar design including:
 - Orientation
 - Shading
 - Cross ventilation
 - Thermal mass
 - Material selection, including low-embodied energy
 - Integrated landscape solution.

C. Viability and Affordability

- Take account for income levels and price points in accordance with the project brief
- Responds to the market brief
- Demonstrates viable returns.

D. Innovation

- Employs innovative and efficient construction techniques and/or building materials to reduce costs and improve affordability
- Varied built form concepts and approaches, including adaptable housing.

Reference: Renewal SA EOI documents for Stage 1A and 1B for the apartment construction cost demonstration project, released May 2014 and July 2014.

Appendix 4: Affordable Housing Price Points

As a guide, the following table provides relevant information on income levels and price points associated with the State Government's Affordable Housing Program:

2015 Affordability Indicators (Moderate Income Only)

Affordability Indicators	Metropolitan Adelaide: 2015
Moderate Income (120% of median annual income)	
Single Person Annual income*	\$75,000
Indicative house purchase price	\$304,000
Indicative weekly rental	\$401
TOD Price Variance - up to	\$349,600

*Upper Income Limits for Households to be eligible to purchase affordable homes are increased to \$95,000 for couples and families with up to three children and a further 8% for each additional independent child.

Refer to the Affordable Homes Program on the State Government website: Income and Asset Limits for the Affordable Homes Program.

While these price points were increased by the State Government in May 2015, the project team based its costings and commercial assessment initially on the price points that applied in 2013-2014.

Appendix 5: IRG participation

The key purpose of the Industry Reference Group (IRG) was to collaborate and engage with industry representative bodies. The IRG met to monitor and input into the progress of the demonstration project as well as ensuring the formal exchange of learnings from the project site.

In particular, the IRG aimed to:

- monitor and provide feedback to the progress of the demonstration project;
- ensure the formal exchange of learnings from the project site to each participating organisation before, during and after any construction; and
- where possible, share technical contributions from members of participating organisations on cost effective medium-density apartment development.

The IRG was not empowered to make key decisions regarding project elements and delivery.

The following is a list of the main engagements of the IRG to date:

- Meeting 1
- Meeting 2
- Meeting 3
- Thursday, 18 September 2014 Thursday, 20 November 2014
- **Progress Report**
- Friday, 24 March 2015 Thursday, 27 August 2015

Friday, 21 March 2014

- Meeting 4 **Final Meeting**

- Tuesday, 9 August 2016

Appendix 6: Project schedule

The project schedule comprised the following key steps:

Timing
Mar-14
Jul-14
Sep-14
Sep-14 to Jun-15
June-15
Nov-16
Nov-16 ~ Oct-17*
Nov-16*

*these dates are indicative only.

Appendix 7: Cost Centres

Cost Centre identification - Hot Spots

Trade Breakdown	Hot Spots	Based on previous like projects	Case study
Site preparation (incl. at grade carpark)	-	1%	4%
Sub Structure	4-5%	4%	4%
Floor and support Systems (superstructure)	10-14%	14%	9%
External Wall Systems	9-12%	12%	15%
Roofing	-	2%	2%
Internal Walls	7-8%	4%	7%
Doors/ Windows	3-4%	4%	2%
External Windows	-	3%	3%
Ceilings & linings	-	4%	5%
Joinery (& cupboards)	5-6%	5%	5%
Handrails, balustrades, fitments in steel frame	-	2%	2%
Floor and wall finishes	4-7%	-	-
 Tiling 	-	2%	1%
 Floor coverings 	-	1%	2%
 Painting and surface finishes 	-	3%	2%
Appliances and equipment	-	1%	1%
Electrical (incl. fire detection)	5-8%	7%	7%
Mechanical/ AC	3-4%	4%	2%
Plumbing (& Sanitary ware) plus Hydraulics	6-7%	6%	6%
Fire services	3-5%	0%	2%
Lift	2-3%	2%	2%
Building sundry works	-	6%	4%
Fencing gates and landscaping	-	1%	1%
Preliminaries			
Overheads and profit	7.9%	12%	12%
Fees and charges			

Appendix 8: Workshops

Site visit 1:16-Sep-14, Mossops, Migrant Centre - ICF concrete pourMossop, Studio 9, Renewal SA - Site visit @ the Migrant Resource Centre





Visual 16: Mossop site visit

Workshop 1:	 9-Oct-14, Presentations workshop at 2.30pm Wall and flooring suppliers, 4 off.
Workshop 2:	 17-Oct-14, Design @ Bowden site visit, Bowden Apartment design experiences To look at transfer of learnings from Bowden that should be applied to the Woodville West apartment demo project
Workshop 3:	 23-Oct-15, Presentations workshop: structural systems: Wall, flooring and cladding suppliers, 4 off.
Workshop 4:	 6-Nov14, Presentations workshop Wall, flooring and cladding suppliers, 4 off. Sustainability
Workshop 5:	 15-Dec-14, Building Management - apartment services workshop (The Square Apartment Project) Workshopping more closely how the building is managed for input consideration of design & cost: upfront and lifecycle
Workshop 6:	 19-Jan-15, Planning Review - apartment project (Woodville West) Preliminary planning review prior to lodging application to DAC
Site visit 2:	 30-Jan-15, Site Visit – modular bathroom pods Modular systems factory site visit

Appendix 9: Designs

Download select drawings from the website: www.renewalsa.sa.gov.au/projects/apartment-cost-demonstration-project

FURTHER INFORMATION

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