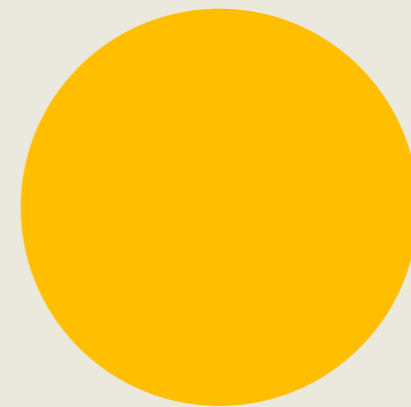


# **CURVULAR: A SOCIAL HOUSING COMPLEX**

FLEETWOOD AUSTRALIA

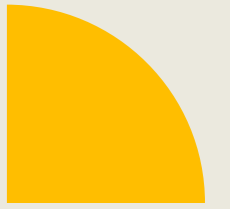
## **CONCEPT DESIGN VALIDATION REPORT**





## CONTENTS

INNOVATION & RESEARCH	1-3
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MATERIALITY //

**LOAD BEARING STRUCTURE**  
SHS Steel Columns



1

**INTERNAL FLOOR MATERIAL**  
Recycled Wood Floorboards



6

**EXTERNAL CLADDING 1**  
Black Colorbond



2

**EXTERNAL FLOOR MATERIAL**  
FireCrunch K-Deck



7

**EXTERNAL CLADDING 2**  
Recycled Timber Cladding



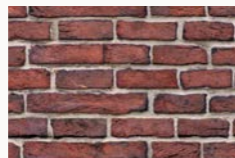
3

**FIRE PROOFING**  
FireCrunch Fire Proofing Layer



8

**EXTERNAL CLADDING 3**  
Recycled Red Brick



4

**ROOF MATERIAL**  
Bi-PV Roof Material



9

**INSULATION**  
RockWool Insulation



5

**INTERNAL CLADDING**  
FireCrunch K-Clad



10



CIRCULAR ECONOMY //

Circular Economy can be defined as a system that restores and regenerates, with the intention to stop the concept of 'end of life', and going towards creating renewable energy and recyclable materials. It looks at the idea of zero waste, throughout all stages of construction. The below materials are used on Curvular and their life capacity and re-use ability is as follows;



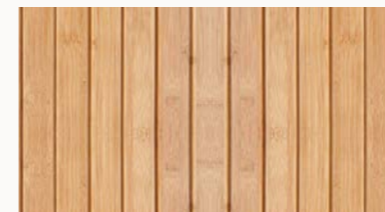
**RED BRICK**

Recyclable in full form: Yes  
Sustainably made: Yes  
Life capacity: 150 years  
Re-useable as: Brick chips, roads, drainage material, fill sand, into new bricks



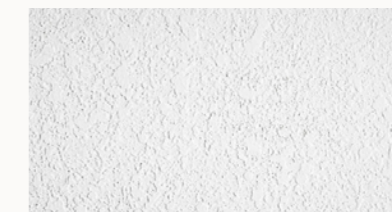
**BLACK COLORBOND**

Recyclable in full form: Yes  
Sustainably made: No  
Life capacity: 70 years  
Re-useable as: New colorbond panelling as its 100% recyclable



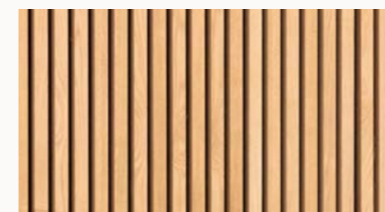
**TIMBER FLOORING**

Recyclable in full form: Yes  
Sustainably made: Yes  
Life capacity: 40 years  
Re-useable as: Furniture, wood chips, particle board, flooring if in good condition



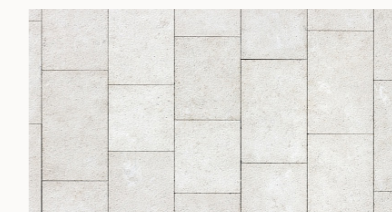
**FIRECRUNCH BOARD**

Recyclable in full form: Yes  
Sustainably made: Yes  
Life capacity: 50 years  
Re-useable as: Cement additive, compost, wastewater treatment, new drywall



**TIMBER CLADDING**

Recyclable in full form: Yes  
Sustainably made: Yes  
Life capacity: 40 years  
Re-useable as: Furniture, wood chips, particle board, cladding if in good condition



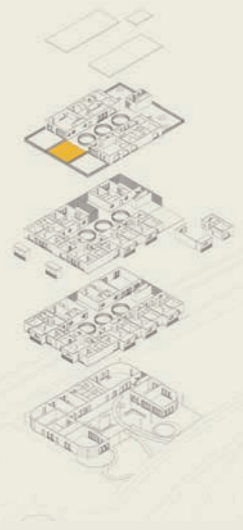
**WHITE PAVING TILES**

Recyclable in full form: Yes  
Sustainably made: Yes  
Life capacity: 45 years  
Re-useable as: Paving tiles if in good condition, potting drainage, gravel, stepping stones



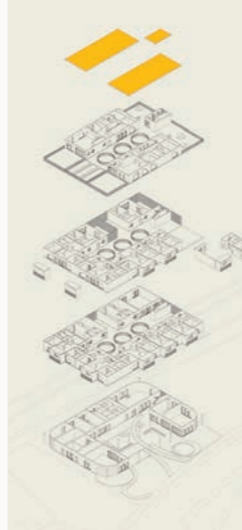
**AQUAPONIC SYSTEM**

Based around the nitrogen cycle that is procuded with fish waste. The plants draw nitrogen from the water, which both feeds the plants and cleans the water, making it safe to return to the fish tank.



**BUIDLING-INTEGRATED PV ROOF**

Solar energy generated directly into a building through the roof material rather than having PV panels on the roof. It looks smooth on the roof, and blends in with the material used.



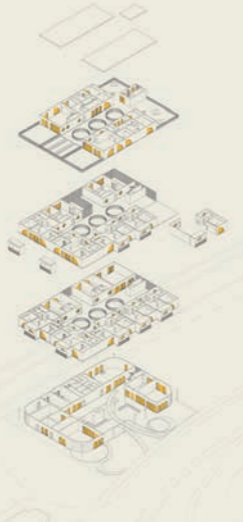
**FIRECRUNCH FLOOR, WALL AND ROOF MATERIAL**

Waterproof, fire resistant (90/90/90), and sustainable cladding for the internal walls, internal roof, and external walkway floors. A lining is also placed on the roof members to improve its fire rating.



**POWER GENERATING GLASS**

Panels are built into the building using solar glasss, which is applied to all windows and glass sliding doors to generate energy.



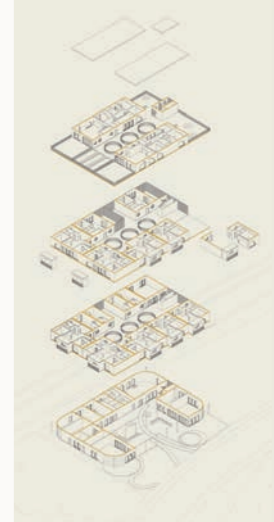
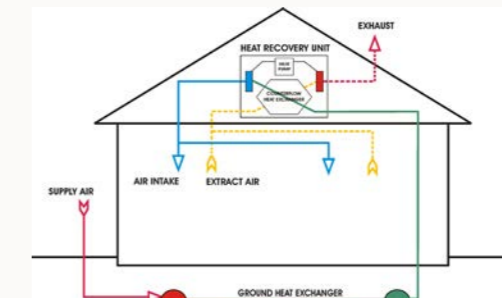
**ROCKWOOL INSULATION**

Made from stonewool, it is environmen-tally friendly, and has high acoustic and fire rating features. It helps with heat loss in the summer, and heat gain in the summer, with a high U value.

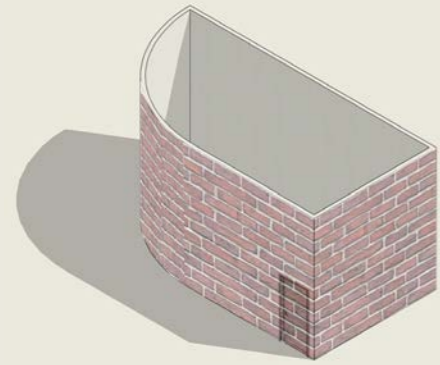


**HEAT RECOVERY AIR SYSTEM**

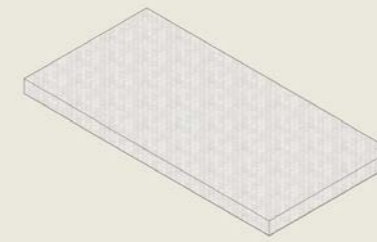
Located inside a service cupboard in each apartment.The system ventilates each apartment with outdoor fresh air, due to the buildings air tightness to achieve net zero.



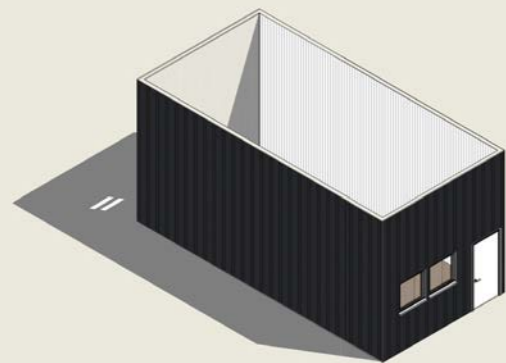
## INNOVATION & RESEARCH DISSASSEMBLY CAPABILITY //



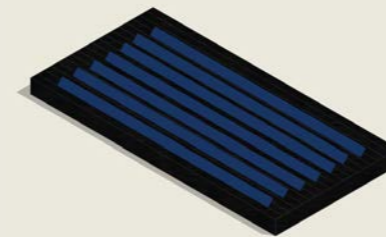
**CURVED MODULE**  
Material: Brick  
Where: Ground Level



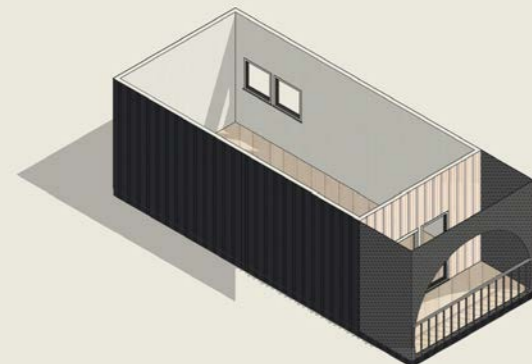
**ROOF TOP TERRACE MODULE**  
Material: Paving  
Where: Level 3



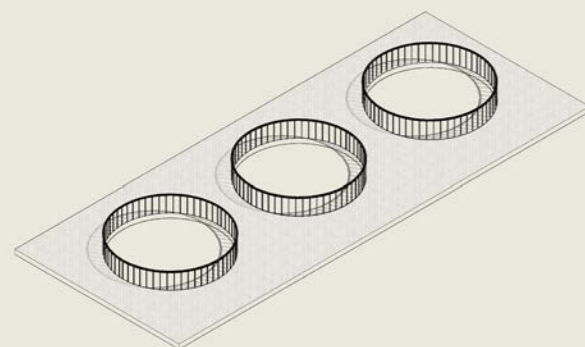
**SQUARE MODULE**  
Material: Colourbond, Firecrunch Board  
Where: Ground, Level 1, 2 & 3



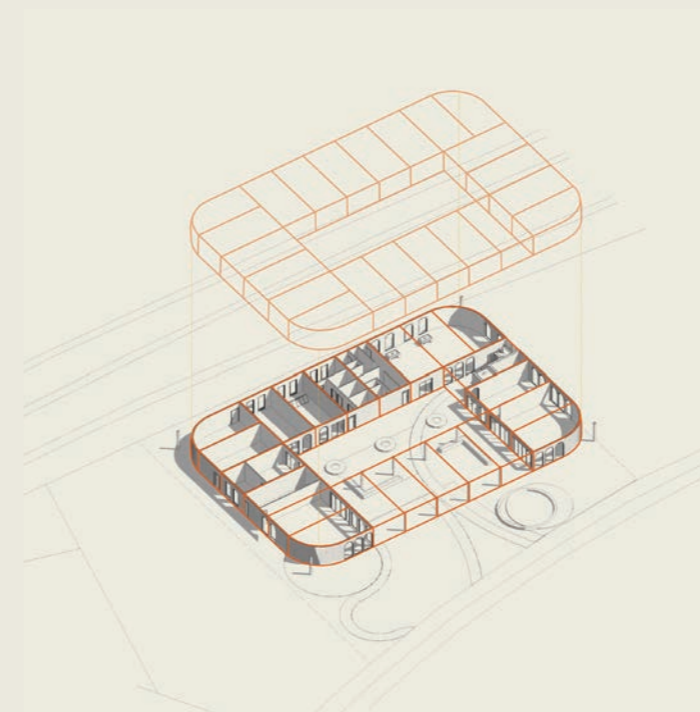
**ROOF MODULE**  
Material: BIPV and ColourBond  
Where: Level 3 (Roof)



**BALCONY MODULE**  
Material: Colourbond, Timber, Firecrunch Board  
Where: Level 1, 2 & 3



**WALKWAY MODULE**  
Material: Paving  
Where: Level 1, 2 & 3

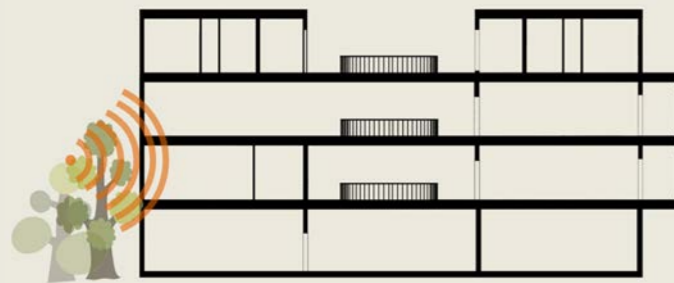


### DESIGN FOR DISSASSEMBLY //

The grid of the building consists of all modules 4.5m by 9m long. This allows for the opportunity to disassemble and assemble the building when needed – also allowing the flexibility to rearrange onto another site if needed.

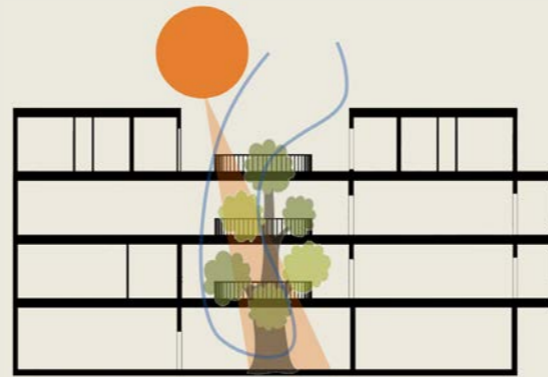
The grid of these modules are placed with the south and west having longer continuous modules to allow the placement of the apartments on the sides to have maximum views of the Coal Dam and the park.





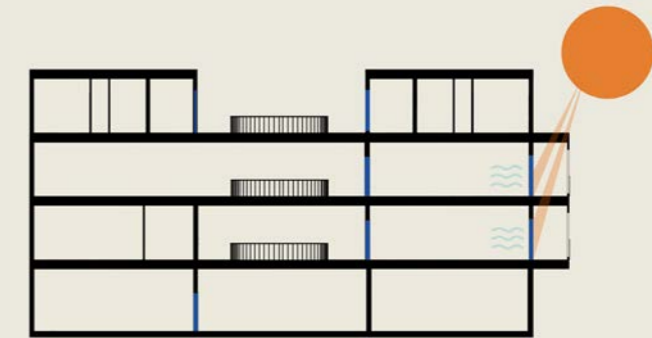
**NOISE ABSORPTION**

Greenery has been placed around the social housing complex to absorb sounds from the train line and surrounding buildings. Insulation and exterior walls have sound absorption properties to also assist with this.



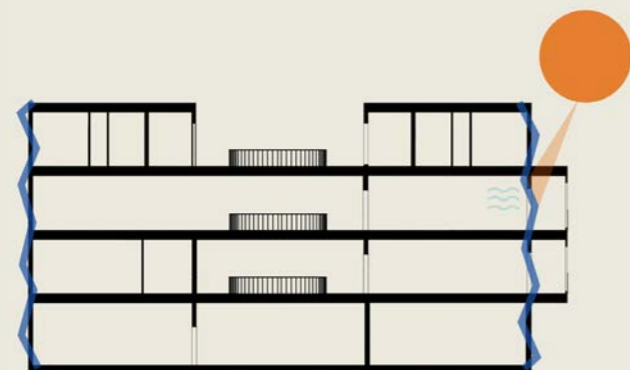
**THERMAL COMFORT**

Thermal comfort is achieved in the building through the use of innovative materials and technological advancements. Rockwool Insulation improves the thermal comfort of the building, as well as double glazed windows.



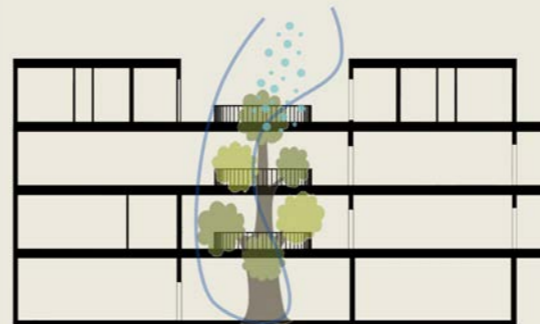
**DOUBLE GLAZED WINDOWS**

Helps with heat in summer, and the cold in winter, due to its double layer of glass with an air gap that traps the heat/cool.



**INSULATION**

Insulation has been used on all internal and external walls, as well as the floor and ceiling. This is to act as a barrier between the heat outside in the summer and the cool in winter - reducing the need to turn on a HVAC system.



**AIR QUALITY & CROSS-VENTILATION**

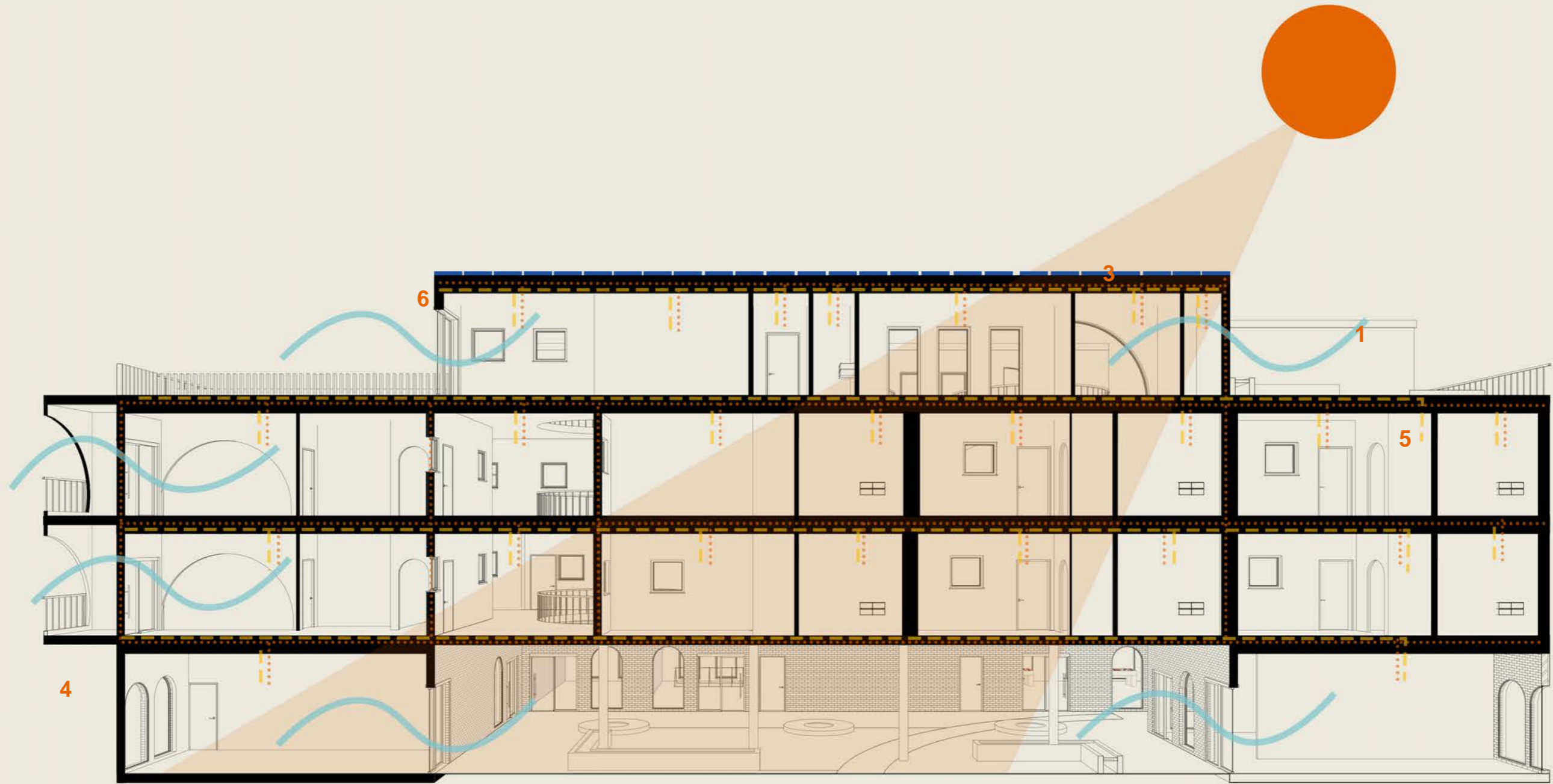
Cross ventilation has been maximised in the development through the use of voids in the centre of the building, and operable windows on each orientation of the building.



**BIOPHILLIA**

Biophilia is present in the design through the addition of greenery and plants around the development, as well as in the courtyard and roof top terrace. This helps with noise absorption and improve the outdoor air quality.

# NET ZERO CONSIDERATIONS



2

- Cross Ventilation 1
- Storm Water Retention System 2
- Solar Panels 3
- Rain Water Tanks 4
- Heat Recovery Ventilation System 5
- Low Energy HVAC System 6



**HELPDESK**

A helpdesk for the residents is provided on the ground floor, this is support services and amenities of the building, aswell as being a helpdesk for the homeless to come to receive services.

**GOVERNMENT SUPPORT SERVICES**

Government support services and offices are included in the ground level of the building. This consists of mental health services such as psychologists and GP's, centrelink and offices that can be rented out to the public.

**AMENITIES**

An amenity filled ground floor has been provided to not only the residents but the surrounding neighbourhood, with the inclusion of a café and lunch bar, a small grocery store, community centre and rented out offices.

**LAUNDRY IN EACH APARTMENT**

Laundries have been included in each apartment to differentiate between the stereotypical social housing complex of shared laundry services. There is a shared room for those who need more services and for the student housing.

**GREEN SPACE**

Green and outdoor space has been a priority for the development, ensuring that each space has their own balcony, and where that isn't possible, a courtyard has been provided. Trees surrounding the property add biophilia to the apartments.

**SHARED COMMUNAL SPACES**

A communal rooftop terrace and community garden is available to the residents, with shared communal walkways that enforce interaction. The ground level courtyard is activated with the staircase only accessible by walk through the courtyard.

**COMMUNITY GARDEN**

A community garden has been provided on the ground level, which uses an innovative aquaponics system to grow the vegetables. This is easily managed by the maintained staff of the development, with limited maintenance needed.

**DIFFERENT APARTMENT SIZES**

A variety of apartment sizes are available in the development, ensuring that residents are living within their means, each with balconies and/or a courtyard. The opportunity to upgrade or downgrade space is an option, due to the helpdesk that's available.

**STUDENT ACCOMODATION**

There is student accommodation available to support students at the Curtin University Campus, with shared communal entertainment area, and amenities on the ground level to service them. The rooms have a small kitchen and study space.





**DESIGN CHARACTER**

The design character has to match the wood-bridge character. Tree lined avenues and strong presence of balconies and verandas - which is evident in my design. It also asks for open spaces which can be seen in the entry courtyard.



**ROOF**

Flat roof or a pitched roof behind a parapet wall is written in the guidelines. This has been matched with a flat roof on all the modules, to keep the line of sight clean.



**LAND USE**

Land use specifies having a cafe and offices on the ground floor - where my design has kept ground level strictly amenities/public access. Guidelines specific levels 1-3 to be residential.



**HEIGHTS + LEVELS**

Floor to floor max is 3.6 per level, which is evident in the design, as the modules are each 3.4m which an allowance of 600mm for ceiling and floor services.



**STREETSCAPE**

Guidelines request a strong streetscape presence and safety, Office spaces visible from street, a Café looking over at Dam/Park on the west - which is evident in the design.



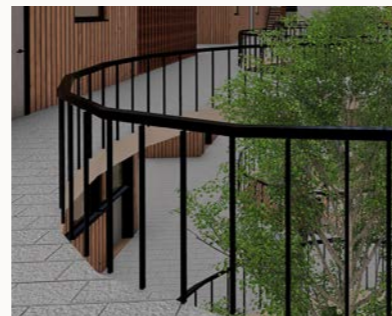
**FACADE**

The design guidelines only mention to interpret the existing rail spur or public art. This has been done with the use of recycled red brick to match the red brick aesthetic of Midland.



**RAILING**

The guidelines state open metal railing with a max height of 1.2m at frontages, 1.8m facing the train track with a colour preference of black. This is all evident on the balconies and walkway voids.

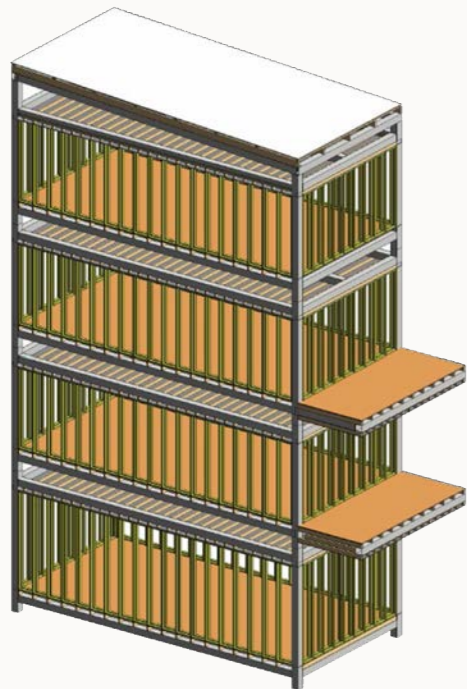


**TYPOGRAPHY**

The planning guidelines show that the site is flat, and the R codes are not available to be viewed. Based on the guidelines, it requested for the block to be used as a mixed-use residential dwelling which is evident in this design.



MODULE CONNECTIONS //

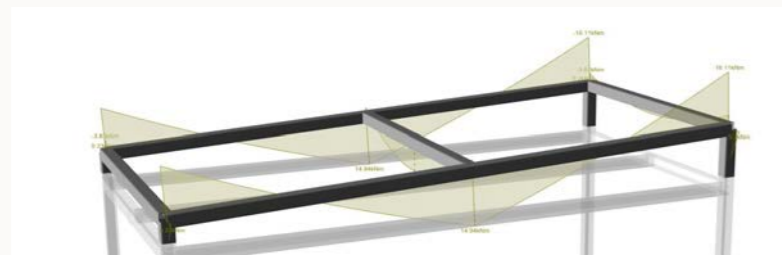


The skeleton frame of the modular units incorporates steel columns and bearers that are welded together. Steel members are chosen as it offers excellent strength, design flexibility and recyclability. On the other hand, roof battens, rafters, floor and ceiling joists, as well as non-load bearing wall studs, are constructed with timber. Using timber reduces carbon footprint which helps move towards a net-zero development. To transfer the loads to the ground, the columns at the ground floor level are supported by concrete pad footings by a "slide in" connection mechanism which is adapted for the vertical column connection as well.

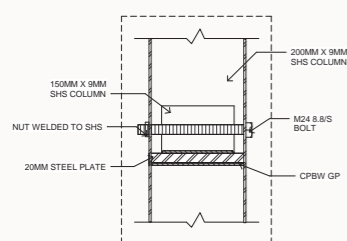
The following connections are considered for the design:

- Ceiling and floor joists are attached to the bearers using joist hangers
- Columns are connected to bearers and beams with 9mm Complete Penetration Butt Welds (GP)
- Stud walls, battens and rafters connected using joist hangers and U Track
- Columns are connected to the footing with base plates and holding down bolts

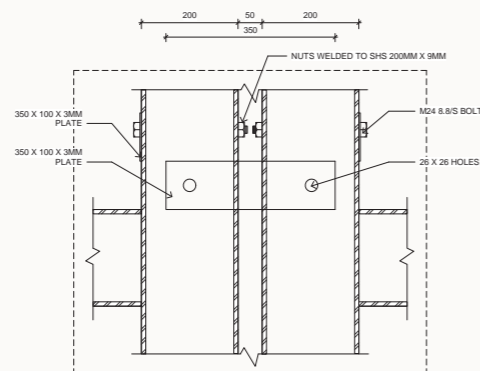
Fire-rated Firecrunch boards will be used to construct the walls, floors, and ceilings to ensure that fire can be properly contained, and the structure can stand for 90 minutes in the event of a fire. Firecrunch is not only lightweight, durable and environmentally friendly, it can also provide a fire resistance of up to 90 mins FLR.



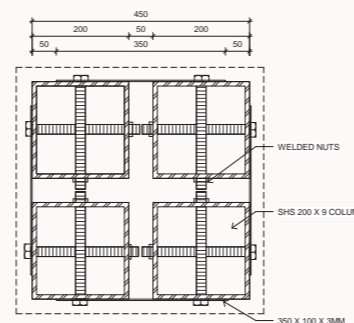
DETAILS //



01 D01 - VERTICAL MODULE CONNECTION  
1:5



02 D02 - 2 WAY HORIZONTAL MODULE CONNECTION  
1:5



03 D03 - 4 WAY HORIZONTAL CONNECTION  
1:5

VERTICAL CONNECTION //

Description	Design Force (kN)	Capacity (kN)
1 x M24 8.8/S	232.16	319
Plate Crushing	116.1	311
Plate Tearing	116.1	194

FOOTING DESIGN //

Column No	Breadth (m)	Thickness (m)	Reinforcement
One	2	0.4	N16@300 c/c
Two	2.6	0.4	N16@300 c/c
Four	3.4	0.5	N16@300 c/c

Pad footings are chosen as the foundation type due to the presence of columns and are designed based on AS3600: 2018. As the floor bearers are not laid directly above the footing, the pad footings are designed to take the moment created by horizontal forces due to wind loads. Therefore, it is designed for both vertical force and moment.

WELDED CONNECTIONS (CRITICAL WELDS) //

All welded connections will be Complete Penetration Butt Welds (GP), with a tt of 9mm. As welded material is stronger than member, member web capacities will be the governing factor.

Description	Bearer/Beam to Column	Bearer to Beam	150x9 SHS to 20mm Plate	200x9 SHS to 20mm Plate
Flange Force	225kN	241kN	243.3kN	182.5kN
Flange Capacity	369kN	369kN	243.4kN	369kN
Web Force	257kN	287kN	312kN	251.5kN
Web Capacity	524kN	524kN	380kN	524kN
Buckling Force	450kN	482kN	487kN	365kN
Buckling Capacity	2120kN	2215kN	1808kN	2120kN

MEMBER DESIGN //

Structure checks have been carried out to verify each member's capability to withstand the bending, compression, tension, deflection, and combined actions. Upon completion of these checks, the SHS200x9 member was found to be satisfactory to all design conditions under the critical load combination, 1.2G + 1.5Q. However, the out-of-plane member capacity of SHS200x9 for each steel structure has been omitted.

Steel Structure	Member Dimension (mm)
External Bearers (8.6m)	SHS 200 x 9
Internal Bearers (8.6m)	SHS 200 x 9
Short Beams (4.1m)	SHS 200 x 9
Columns (3.9m)	SHS 200 x 9

INTERNAL BEARER //

Internal Bearer		
	Design Action	Design Capacity
Bending(kNm)	M*= 55.5	$\phi M_s = 188$
Shear(kN)	V*= 46.07	$\phi V_v = 786$
Compression(kN)	Nc*= 2.36	$\phi N_{cx} = 1513.8$

Shear Bending Interaction	
V*/ $\phi V_v$ (kN)	M*/ $\phi M_s$ (kN)
0.0586 < 0.6	0.29 < 0.75

Serviceability Deflection	
L/250 Criteria	$\Delta_{max}$
34.4 mm	24.49 mm

Serviceability Limit Criteria - <AS4100:2020 Appendix B>

EXTERNAL BEARER //

External Bearer		
	Design Action	Design Capacity
Bending(kNm)	M*= 26.16	$\phi M_s = 188$
Shear(kN)	V*= 31.26	$\phi V_v = 786$
Compression(kN)	Nc*= 61.86	$\phi N_{cx} = 1513.8$

Shear Bending Interaction	
V*/ $\phi V_v$ (kN)	M*/ $\phi M_s$ (kN)
0.04 < 0.6	0.14 < 0.75

Serviceability Deflection	
L/250 Criteria	$\Delta_{max}$
34.4 mm	10.29 mm

Serviceability Limit Criteria - <AS4100:2020 Appendix B>

Combined Action	
Bending + Compression	
Design Action	Design Capacity
M*=26.16	$\phi M_{rx} = 222.94$

Combined Action	
In Plane Member Capacity	
(M*/ $\phi M_{sx} + N*/ \phi N_{cx}$ )	
0.2104 < 1	

SHORT BEAM //

Short Beam		
	Design Action	Design Capacity
Bending(kNm)	M*= 28.23	$\phi M_s = 188$
Shear(kN)	V*= 24.48	$\phi V_v = 786$
Compression(kN)	Nc*= 38.15	$\phi N_{cx} = 1513.8$

Shear Bending Interaction	
V*/ $\phi V_v$ (kN)	M*/ $\phi M_s$ (kN)
0.0311 < 0.6	0.1501 < 0.75

Serviceability Deflection	
L/250 Criteria	$\Delta_{max}$
16.4 mm	4.95 mm

Serviceability Limit Criteria - <AS4100:2020 Appendix B>

Combined Action	
Bending + Compression	
Design Action	Design Capacity
M*=28.23	$\phi M_{rx} = 218.5$

Combined Action	
In Plane Member Capacity	
(M*/ $\phi M_{sx} + N*/ \phi N_{cx}$ )	
0.1605 < 1	

COLUMN //

Column		
	Design Action	Design Capacity
Bending(kNm)	M*= 52.05	$\phi M_s = 188$
Shear(kN)	V*= 71.56	$\phi V_v = 786$
Compression(kN)	Nc*= 302.35	$\phi N_{cx} = 1513.8$

Shear Bending Interaction	
V*/ $\phi V_v$ (kN)	M*/ $\phi M_s$ (kN)
0.09 < 0.6	0.276 < 0.75

Serviceability Deflection	
L/200 Criteria	$\Delta_{max}$
45 mm	8.85 mm

Serviceability Limit Criteria - <AS4100:2020 Appendix B>

Combined Action	
Bending + Compression	
Design Action	Design Capacity
M*=52.05	$\phi M_{rx} = 193.71$

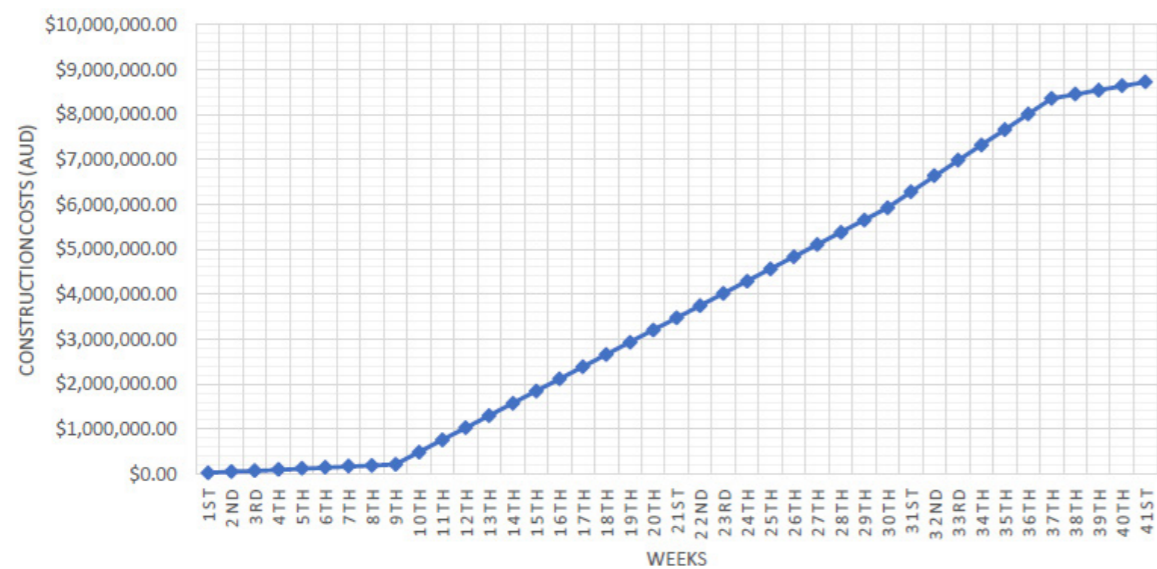
Combined Action	
In Plane Member Capacity	
(M*/ $\phi M_{sx} + N*/ \phi N_{cx}$ )	
0.415 < 1	

COSTING //

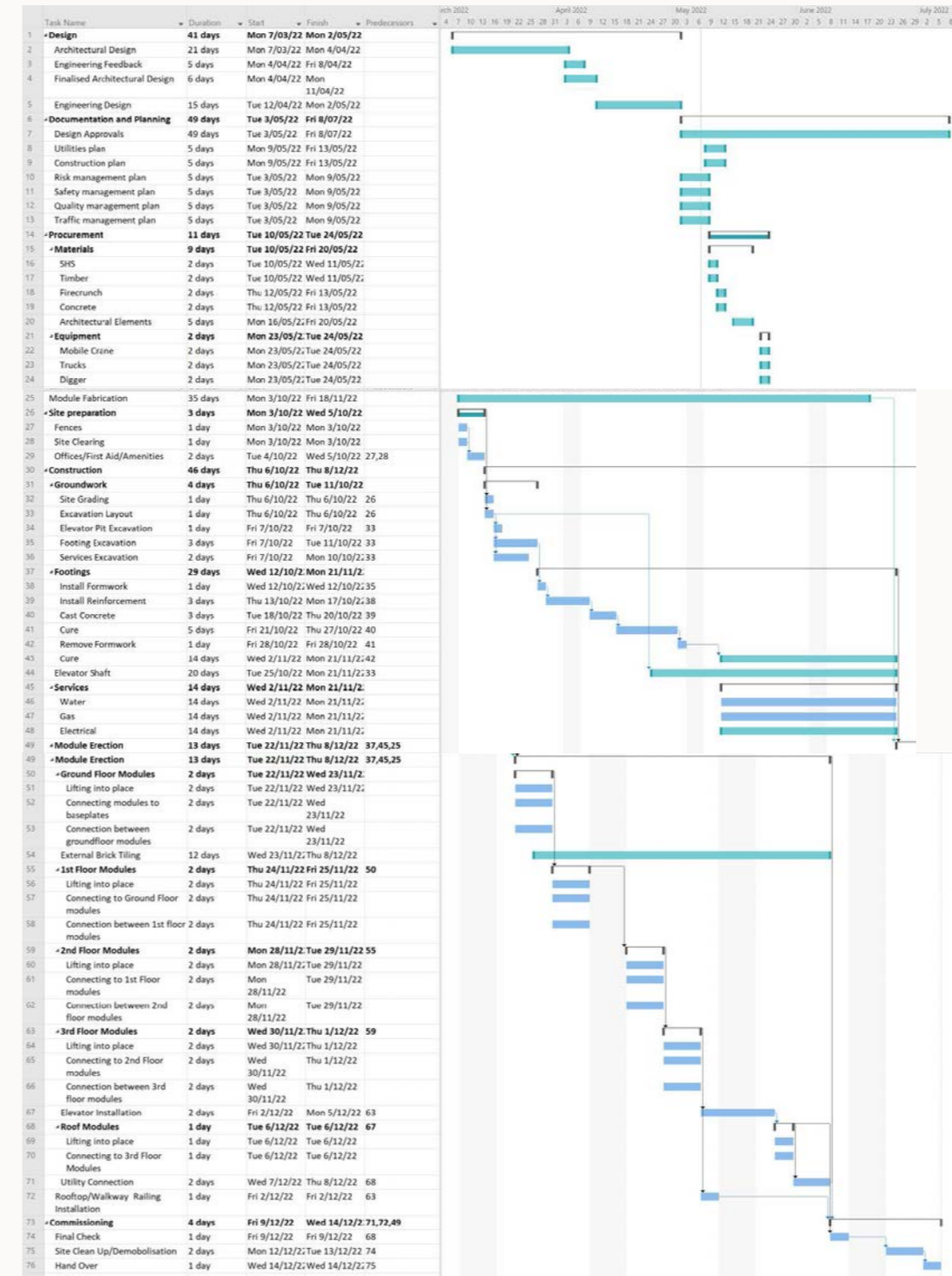
CESMM4 Classification	Description	Cost (\$AUD)
A	General items	\$472,221.20
D	Site clearance	\$1,520.00
E	Earthworks	\$10,188.16
F	In situ concrete	\$45,398.40
G	Concrete ancillaries	\$8,574.90
M	Structural metalwork	\$4,079,260.80
O	Timber	\$594,123.78
W	Waterproofing	\$14,232.27
Z	Simple building works	\$847,474.32
	<b>Total Cost</b>	<b>\$6,072,993.82</b>
	Contingency (10%)	\$607,299.38
	GST (10%)	\$607,299.38
	Overhead & Profit Markup (7.5%)	\$455,474.54
	<b>Total Construction Cost</b>	<b>\$7,743,067.12</b>

S - CURVE

Total Cumulative Cost



SCHEDULE GANTT CHART //



“BIPV: Building-Integrated Photovoltaics, The Future Of PV | Solar Choice”. 2022. Solar Choice. <https://www.solarchoice.net.au/blog/bipv-building-integrated-photovoltaics-the-future-of-pv/>.

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