SITE ANALYSIS

Commercial

Restaurant

Education & Culture

Health
- Clinic
- Hospital
- Pharmacist

Wind direction
- 9am: NE & E
- 3pm: SW & W

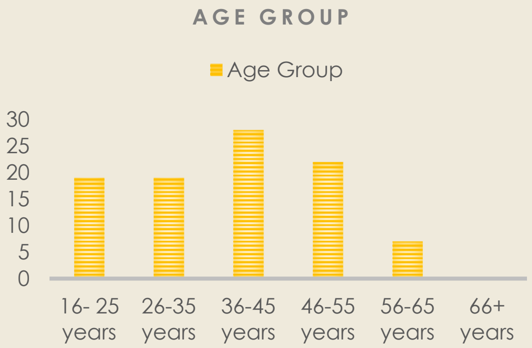
Sun path

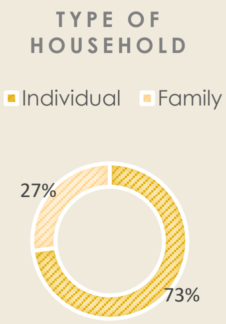
Accessibility
- Primary roads

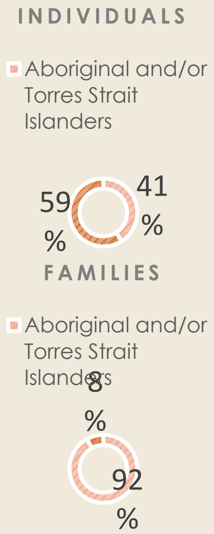
Public Transport

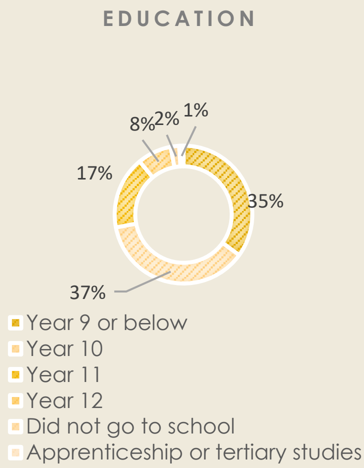
INFOGRAPHIC

HOMELESS









The site on lot 49 in Victoria Street was chosen due to its accessible opportunities around the area for the social housing community, both socio-economic opportunities and some educational opportunities which could and would be beneficial for the social housing community when (re)-entering the society. In addition, its location is near the public transport, which is convenient to get around

Social Housing

Homeless /
Low Income Households

<u>Sub-concept:</u>

'Rehabilitation Of The Community By Proposing Camping Programs And Adapting Them To The Social Housing.'

Camping Programs Can Help People Who Feel Isolated Or Misunderstood Because Of Their Conditions, Challenges Or Circumstances. Camp Offers Connectivity And Support Needed To Finally Feel Like Part Of A Community, A Place To Belong, A Place For The Community To Relate.

Programs

Workshop & Training

To prepare and help the community learn skillsets before entering society and employment opportunities.

- Flexible community area for workshops, training, and events (with the Soltex retractable roof and solar screen) on level 3

Participation & Engagement

To empower the residents through participation and involvement in the community and engagement and create a sense of belonging.

- Community area that provides barbeque space to allow people to interact and engage on the ground floor

Community Garden And Solar Energy

To contribute and allow the community to be self-sustain in terms of food and energy.

- Community garden on level 1
- PV system: solar ivy on east and west facade

Health

To provide and encourage the community to care for their health or outdoor activity.

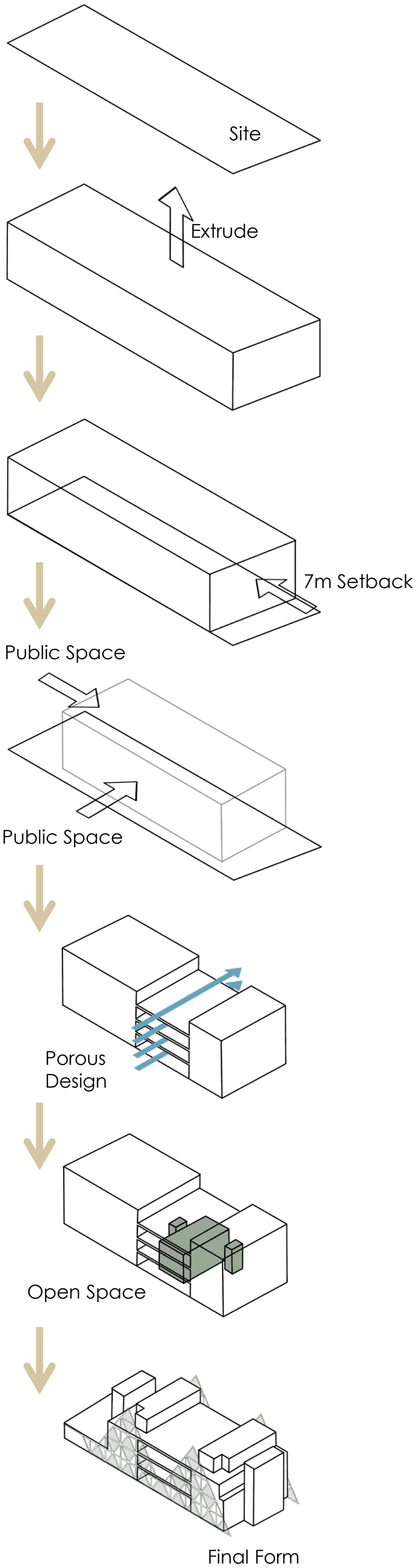
- Outdoor gym on the ground level

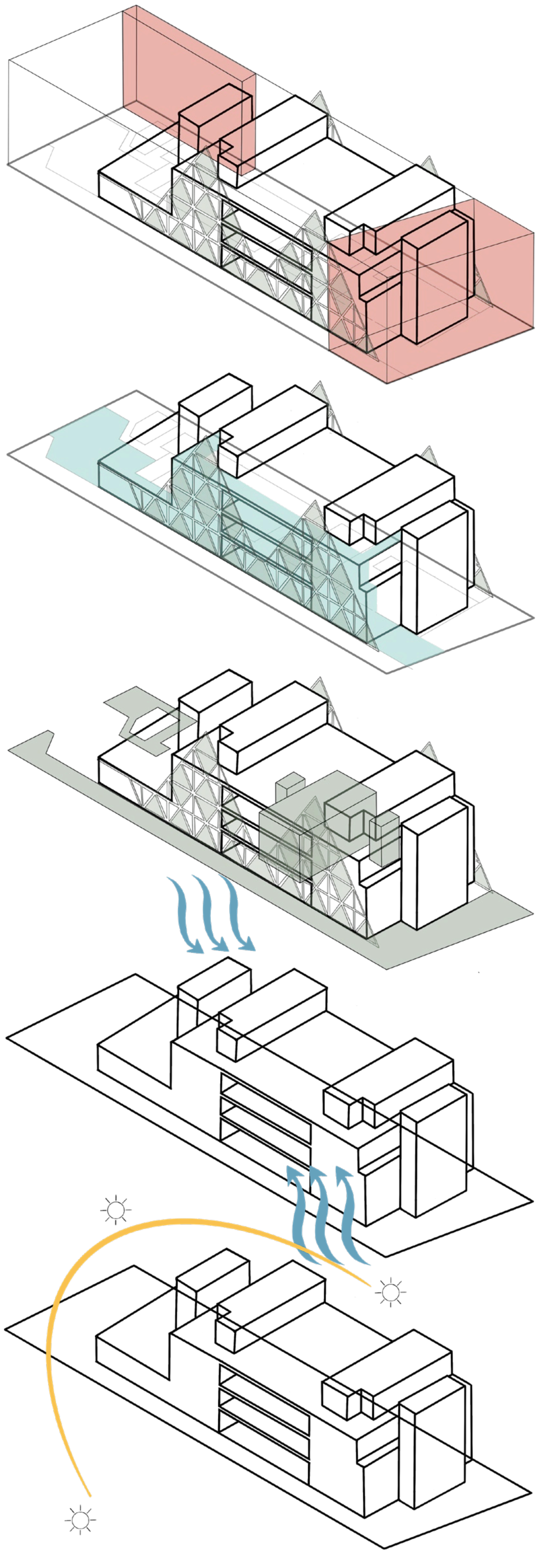
The design is a social housing that caters to homeless and low-income household members. Besides its goal to contribute to achieving Net Zero by 2050 with the main concept of 'Achieving Net Zero Begins at Home', the design embraces a sub-concept of 'Rehabilitation of the Community by Proposing Camping Programs and Adapting them to the Social Housing.' Camping programs can help people who feel isolated or misunderstood because of their conditions, challenges or circumstances. Camp offers connectivity and support needed to finally feel like part of a community, a place to belong, a place for the community to relate. The programs such as Workshop & training, participation & engagement, garden & renewable energy, and health are adopted and incorporated in the form of facilities into the design to prepare and help the community learn skillsets before entering society and employment opportunities, to empower the residents through participation and involvement in the community and engagement and create a sense of belonging, to contribute and allow the community to be self-sustain in terms of food and energy, and to provide and encourage the community to care for their health or outdoor activity.

NET ZERO AND INNOVATION

FORM AND LAYOUT

The form and layout of the Design were influenced by and adapted to the local climate and context. The form and layout allow cross-ventilation, contributing to passive heating and cooling within the design. Furthermore, with optimal use of natural lighting in the living areas, the quality of life can be improved, and artificial lighting can be reduced. Hence, it can help with energy-saving, reduce electricity costs and Net-Zero within the building.





Setback:
- Front – nil
- Side – nil for 2/3 length of the boundary
- Rear – 7m

Access:
- Design entry point – Victoria street (north)
- Corridors' access – west

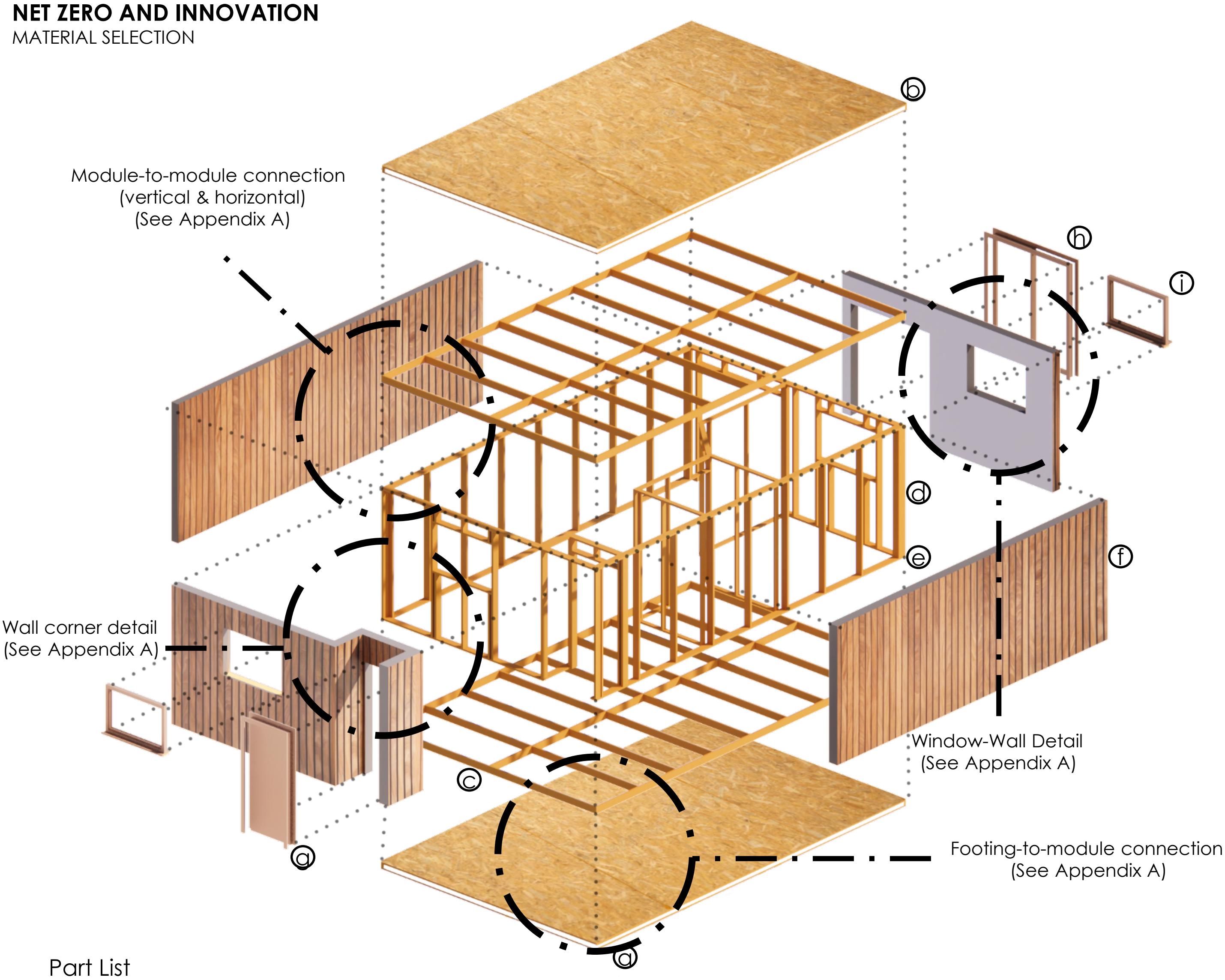
Green and open space:
Green spaces surround the design and open green space in the middle of the building.

Wind:
The wind from both the northeast and southwest goes through the building because of its porosity.

Sun;
The module living areas are mostly positioned on the east side of the building. Hence, the areas can get enough natural light for residents' daily activities.

NET ZERO AND INNOVATION

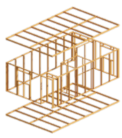
MATERIAL SELECTION



Part List

A. SIP floor panel
B. SIP roof panel
C. 140x90mm F17 Jarrah: timber floor bearer
D. 140x45mm MGP10 Pine: spline
E. 140x35mm MGP10 Pine: base plate
F. Sip wall panel with external timber cladding
G. Painted timber door
H. Aluminium sliding 2 glazed panels
I. Aluminium double glazed window

Timber

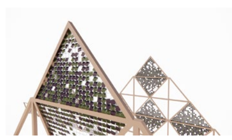


The design will primarily utilise timber construction as wood captures carbon and reduce co2 in the atmosphere. In addition, there is a natural, renewable material, and it has low embodied energy. Furthermore, the types of timber that will be utilised in the construction are MGP10 Pine and F17 Jarrah, which both of them can be found locally, and they are a cheaper and more sustainable option compared to steel and concrete.

SIP Panels

Sip panels will be utilised for each module's flooring, wall, and roof. The Sip panel contributes to a decrease in heat transfer and has great energy efficiency. Hence, the utilisation of artificial heating and air conditioning can be reduced. Furthermore, it is a sustainable material with good fire insulation and is flexible in terms of configuration and connection. In addition, the sip panel also contributes to improved indoor air quality, minimal waste, faster project completion, minimal construction errors, fewer labour requirements, and so on, which helps in reducing the overall construction cost and in achieving net-zero (See Appendix C and D for timeline and costing).

Steel

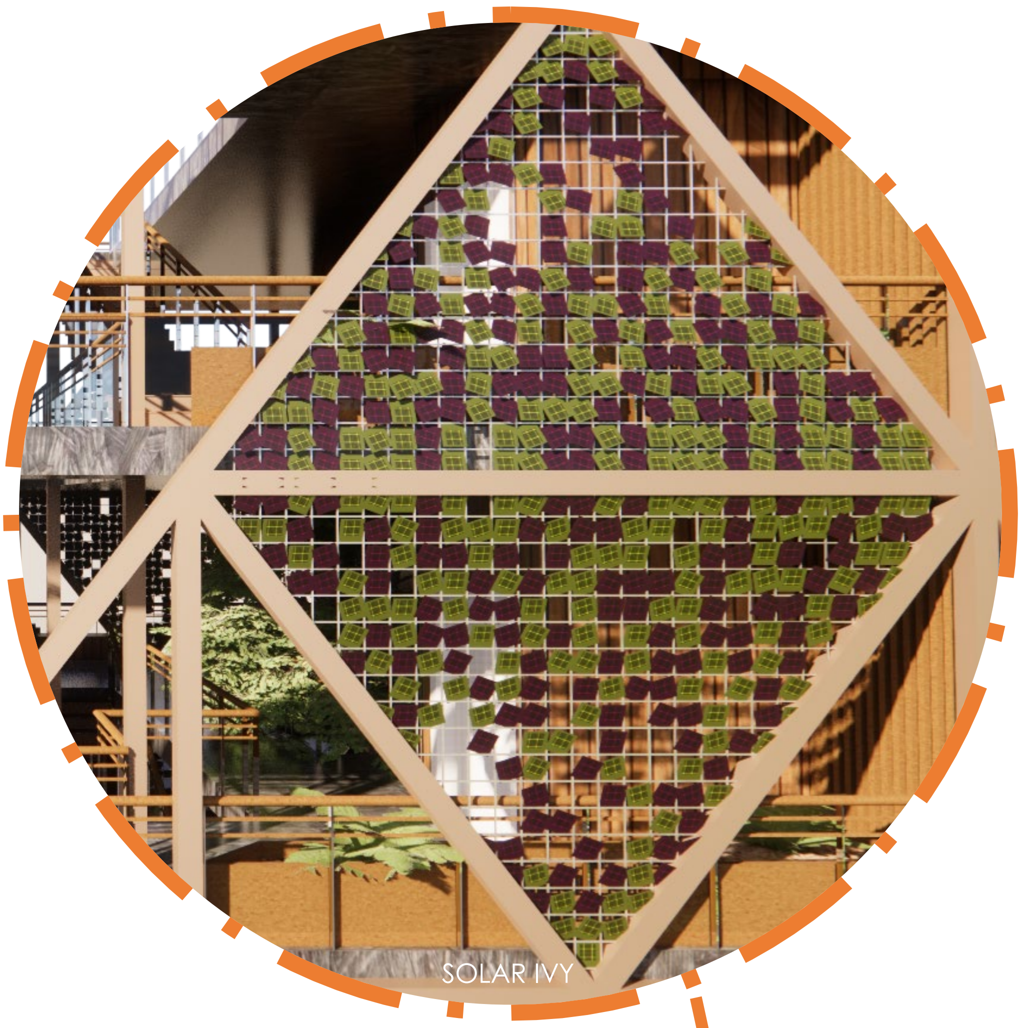


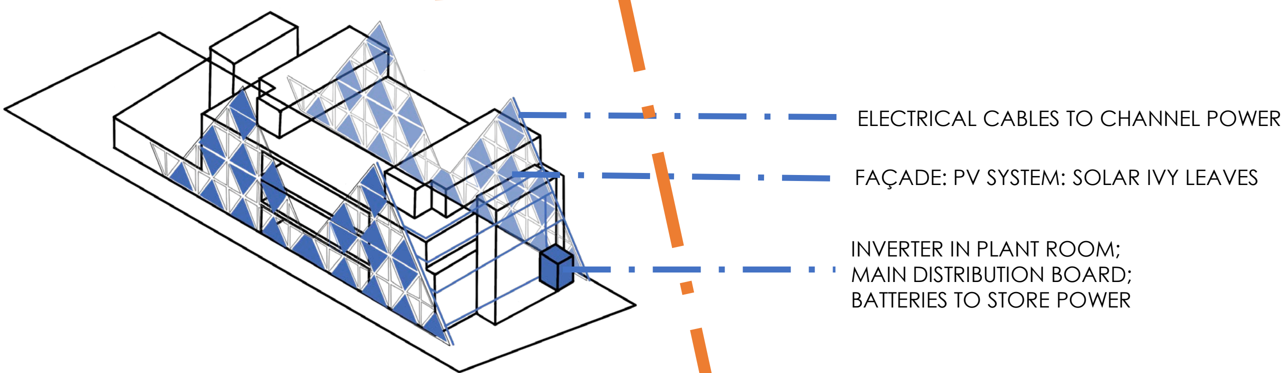
Steel will be utilised for the proposed design's façade system. It is strong and sustainable as it is recyclable, reusable, lasts long, and low maintenance. Furthermore, it is flexible as it is easy to assemble and dissemble.

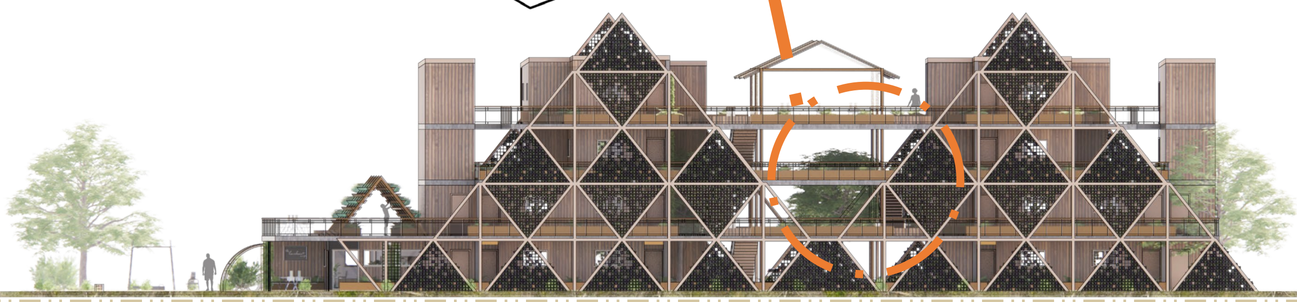
NET ZERO AND INNOVATION

PV SYSTEM: SOLAR IVY

The design will be utilising a PV system: Solar Ivy. Whilst it captures the sun's energy and generates electricity like the other PV systems, it also reflects nature's organic essence, resembling ivy leaves. It can also act as a shade screen that minimises solar heat gain and can be bent to create various curved or rigid shapes or be mounted to contour the outer surface of a structure. The incorporation of PV System: solar ivy leaves on both east and west sides allows the system to generate energy which allows the community to self-sustain energy and helps reduce the electricity cost and lifestyle. An average of 500 solar ivy leaves are recommended for one residential, which could generate about 250 watts. On top of that, the excess energy can be saved in a battery located in the plant room or be transferred to the grids, which allow the social housing community to be paid for their electricity contribution to the macro community.







Section A: Governing Requirements

Part A6: Building Classification

A6.**2** Class **2** Buildings
(1) A Class 2 building is a building containing two or more *sole-occupancy units*.
(2) Each *sole-occupancy unit* in a Class 2 building is a separate dwelling.

Definition of '*sole occupancy unit*':
A room or other part of a building for occupation by one or joint owner, lessee, tenant, or other occupier to the exclusion of any other owner, lessee, tenant, or other occupier and includes –
(a) A dwelling; or
(b) A room or suite of rooms in a Class 3 building which includes sleeping facilities; or
(c) A room or suite of associated rooms in a Class 5,6,7,8 or 9 building; or
(d) A room or suite of associated rooms in a Class 9c building, which includes sleeping facilities and any area for the exclusive use of a resident.

A6.**6** Class **6** Buildings
A Class 6 building is a shop or other building used for the sale of goods by retail or the supply of services direct to the public, including –
(1) An eating room, café, restaurant, milk or soft-drink bar; or
(2) A dining room, bar area that is not an assembly building, shop or kiosk part of a hotel or motel; or
(3) A hairdresser's or barber's shop, public laundry, or undertaker's establishment; or
(4) A market or sale room, showroom, or service station.

Section B: Structure

PART B1: Structural Provisions

Structural System
SIPs panels are the main structure to build up the module. The concept of SIPs panel due to its characteristics, wall panel, mixing with timber spline can act as a column structure to support structure above. On the other hand, the timber floor bearer plays the role of the beam to support the floor panel and over-hanging part.
- 140x90mm F17 Jarrah for floor bearer
- 140x45 MGP10 Pine for spline and base plate
- SIPs panel for wall, floor, and roof

Interfaces
This structure works as a whole by stacking up one module on one module without letting them fail, and the module connection is added to strengthen the stability of the whole structure.

Material Choice
All the materials used for the design would be timber-based products. Structural Insulated Panel (SIP) is a timber-based product that includes SIPs wall panels, floor panels and roof panels. We chose timber as the main material because it is an eco-friendlier construction material and SIPs are known for their flexibility and short construction period. Using the combination of timber frames and SIPs can enhance the structure's overall structural performance. This panel offers several benefits such as fire resistance, thermal insulation, quick construction process, and improved environmentally friendly. A fire rating of 60/60/60 to 90/90/90 can be reached when applied with suitable cladding.
Jarrah has been selected for the bearer and joists for the design, and MGP10 (Machine-Graded Pine) has been selected for columns. Jarrah timber has strong weather and termite resistance, making it ideal for outdoor use. It also has the potential on fire-resistant due to its density. On the other hand, MGP10 timber has a higher stiffness grade which is suitable for column construction.

Design Combine Loading
The wall proposed is to be a SIPs panel; it is assumed that the sway action caused by wind is to be bear and restrained by the SIPs panel as a SIPs panel can also be classified as a structural element itself. SIPs panels can withstand wind action in Australia's most critical wind region, which is the wind region D (cyclonic). Hence, the capacity of SIPs panels to withstand the wind action can be considered enough for the proposed site, which is located in wind region A4 (slower wind speed).

Conclusion
The analysis conducted by the engineers shows that the overall design of the module is feasible as members are available locally, and prefabrication can be done. The design capacity of each member has been calculated in detail and has proven to be able to handle the loads (See Appendix B for Engineering Analysis).

Section C: Fire Resistance:

Part C1: Fire Resistance and Stability

C1.1 Type of Construction Required

The Rise in Storeys: 4
Class of Building: Class 2 and 6
Type of Construction: A

C1.2 Calculation in the Rise of Storeys:

(a) The rise in storeys is the sum of the greatest number of storeys at any part of the external walls of the building and any storeys within the roof space—
(I) Above the finished ground next to that part; or
(II) If part of the external all is on the boundary of the allotment, above the natural ground level at the relevant part of the boundary.

Hence, this building has four storeys.

C1.3 Buildings of Multiple classifications

The proposed design is a 4-storey building with multiple classifications of Class 2 and Class 6. The main type of construction of this design is A. Hence, the requirement of construction type A is required to be applied to all storeys.

C1.8 Lightweight Construction

The proposed design utilised timber construction which is considered lightweight construction. This design's wall, floor, and roof system utilises SIPs panels which can offer FRL of 60/60/60 or 90/90/90 when applied with suitable cladding.

C1.9 Non-Combustible Building Elements

The wall system: external and internal walls within the building incorporate plasterboards, a non-combustible element.

Section D: Access and Egress

Part D1: Provision for escape

D1.2 Number of Exits required

The proposed design has at least two exits from each storey.

D1.3 When fire-isolated stairways and ramps are required

The proposed design is a 4-storey building with multiple classifications of Class 2 and Class 6. Hence, fire-isolated stairways are required and incorporated into the building.

D1.4 Exit Travel distances

The entrance doorway of any sole-occupancy unit within the proposed design is not more than 6m from an exit or from a point from which travel in different directions to 2 exits is available.

D1.5 Distance between alternative exits

The exits within the proposed design are evenly distributed within the storey served and in positions where unobstructed access to at least two exits is readily available from all points on the floor, including lift lobby areas, and not more than 45m apart in Class 2 or 3.

D1.6 Dimensions of exits and paths of travel to exits

The clear height of the path of travel to an exit of the proposed design is not less than 2m, and the unobstructed width is not less than 1m.

Part D2: Construction of Exits

D2.13 Goings and Risers

Each stairway within the design has not more than 18 and no less than two risers in each flight.

D2.17 Handrails

The height of handrails within the building is mostly 930mm (criteria: not less than 865mm).

Part D3: Access for people with a disability

D3.1 General Building Access Requirements

the proposed design allows sole-occupancy units to be accessible from the pedestrian entrance. In addition, spaces commonly used by the community are mostly located on that specific level, allowing easy access for people with disability. On top of that, the design provides a lift for easy access throughout the storeys.

Part D3: Access for people with a disability

D3.1 General Building Access Requirements

the proposed design allows sole-occupancy units to be accessible from the pedestrian entrance. In addition, spaces commonly used by the community are mostly located on that specific level, allowing easy access for people with disability. On top of that, the design provides a lift for easy access throughout the storeys.

Section E: Services and Equipment

Part E1: Fire Fighting Equipment

E1.2 Fire Extinguishers

The design provides fire extinguishers near every fire-prone area, module, and public space.

E1.3 Fire Hydrant

Fire Hydrant will be located on the ground floor of the building.

Part E4: Visibility in an emergency, exit signs and warning systems.

E4.2 Emergency lighting requirements

The design incorporated emergency lighting in every fire-isolated stairway.

E4.5 Exit signs

The design provides exit signs within the enclosed stairways and a passageway or horizontal exits.

Section F: Health and Amenity

Part F3: Room Heights

F3.1 Height of Rooms and other Spaces

The height of rooms and other spaces must be not less than –
(a) In a Class 2 or 3 building or Class 4 part of a building –
i. A kitchen, laundry, or the like – 2.1m; and
ii. A corridor, passageway or the like – 2.4m; and
iii. A habitable room excluding a kitchen – 2.4m
(b) In a Class 5,6,7 or 8 building –
i. Except as followed in (ii) and (f) – 2.4m; and
ii. A corridor, passageway, or the like – 2.1m

The overall height of the spaces within the proposed design is not less than 2.4m.

Part F4: Light and Ventilation

F4.1 Provision of Natural Light

Natural light must be provided in:
(a) Class 2 buildings and Class 4 parts of buildings – to all the habitable rooms.

All the habitable rooms within the building have access to natural light, whether directly from the outside or borrowed light from the adjoining room.

F4.3 Natural light borrowed from the adjoining room

(a) Natural light to a room in a Class 2 or Class 4 part of a building or in a sole-occupancy of a Class 3 building may come through one or more glazed panels or openings from an adjoining room (including an enclosed verandah) if—
i. both rooms are within the same sole-occupancy unit or the enclosed verandah is on common property; and
ii. the glazed panels or openings have an aggregate light-transmitting area of not less than 10% of the floor area of the room to which it provides light; and
iii. the adjoining room has – i. a window, excluding roof light, that – 1. have an aggregate light-transmitting area of not less than 10% of the combined floor areas of both rooms; and
2. are open to the sky or face a court or other space open to the sky or an open verandah, carport or the like; or

Some of the habitable rooms on level 1 do not directly access the natural light. Therefore, the system of borrowing natural light from adjoining rooms is incorporated.

F4.4 Artificial Lighting

The design incorporates artificial lighting throughout the building; habitable rooms, non-habitable rooms, and public spaces.

F4.5 Ventilation of Rooms/ F4.6 Natural ventilation/ F4.7 Ventilation Borrowed from Adjoining Room.

All the habitable rooms within the design are incorporated with natural ventilation in the form of either opening windows, doors or other devices which can be opened.

F4.8 Restriction on Location of Sanitary Compartments
The sanitary compartments within the proposed design are not open directly into a kitchen, pantry, public dining room, or restaurant.

F4.9 Airlocks
Exhaust ventilation is incorporated into the sanitary components throughout the proposed design.

F4.12 Kitchen Local Exhaust Ventilation
Kitchen exhaust hoods are incorporated throughout the kitchen area within the building.

Part F4: Light and Ventilation
F5.4 Sound Insulation Rating of Floors/ F5.5 Sound Insulation Rating of Walls
The building utilises SIP panels for flooring, wall and roof. Most SIPs have good Sound Transmitting Characteristics (STC) scores (above 50) for airborne noises and Impact Insulation Class (IIC) scores (below 40).

Section J: Energy Efficiency

Part J0: Energy Efficiency

J0.3. Ceiling Fans
To satisfy the design requirements, ceiling fans are permanently installed in the habitable rooms throughout the building.

Part J1: Building Fabric
J1.2 Thermal Construction – General
The building primarily utilises SIP panels offering different insulation values throughout different thicknesses. SIP panel with a thickness of 145mm is utilised for the external walls of the building; it has an insulation value of R3.57. On the other hand, a 115mm thick SIP panel is mainly used for internal walls with an insulation value of R2.8.

Part J6: Artificial Lighting and Power
J6.3 Interior Artificial Lighting and Power Control
A switch and another control device individually operate all artificial lighting of a room or space.

J6.5 Exterior Artificial Lighting
Exterior artificial lighting incorporated in the building is controlled by a daylight sensor or a time switch (pre-programmed times/days).

J6.6 Boiling Water and Chilled Water Storage Units
A time switch controls the power supply to the boiling or chilled water storage unit.

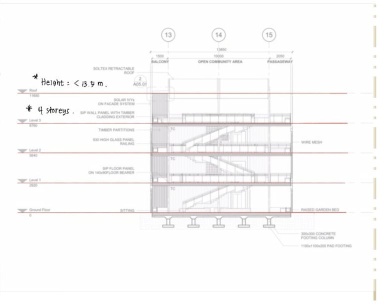
J6.7 Lifts
Artificial lighting and ventilation installed in the car are configured to go off when it is unused for 15 minutes
.
Part J8: Facilities for Energy Monitoring
The building has an energy meter configured to record the time-of-use consumption of gas and electricity.

Conclusion
According to the analysis above, it can be concluded that the proposed design is deemed to comply with the NCC 2019 design criteria. However, further building assessment is required to understand the properties and characteristics fully.

PLANNING COMPLIANCE
'MRA MIDLAND DESIGN GUIDELINE'

Podium Setbacks (Min)			Height	Storeys	
Front	Side	Rear	Up to 13.5m	Min	Max
Nil	Nil for 2/3 length of the boundary	7m		2 Storeys	4 Storeys


Setbacks

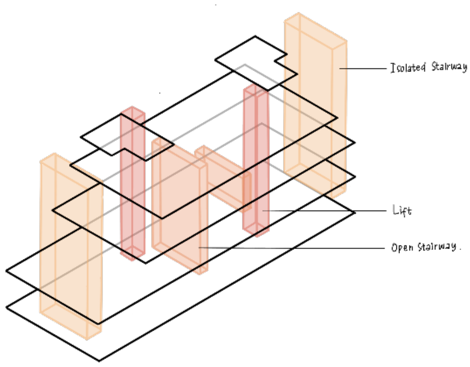

Storeys and Height

SERVICES

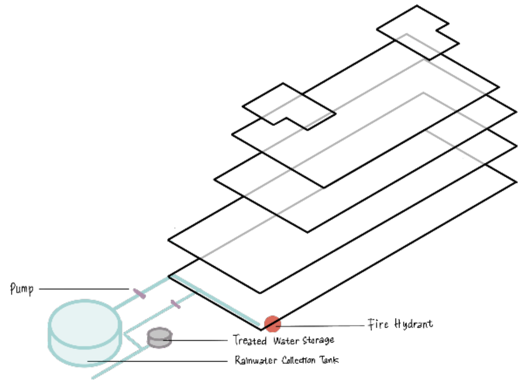
Fire

The design will provide several fire-fighting equipment such as a fire extinguisher/ fire blanket throughout the modules or fire-prone areas within the building, such as the kitchen and community BBQ area, and a fire hydrant near the entrance point on ground level. The water for the fire hydrant will be pumped from the rainwater and treated water collection storage.

The design will also incorporate emergency lights in every fire-isolated stairway in case of emergency and exit signs where appropriate along the passageway, horizontal exits, and fire-isolated stairways.

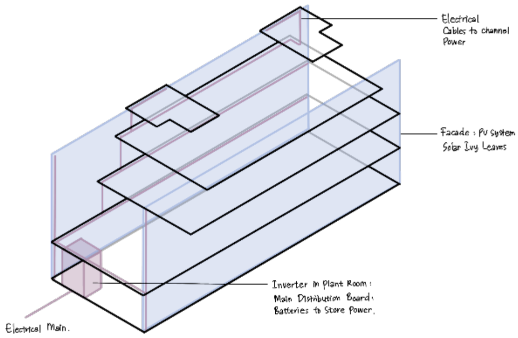


Exits Accesses



Fire Hydrant

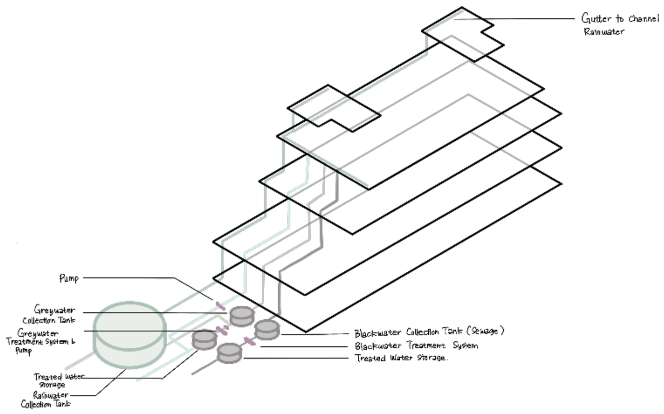
Electricity



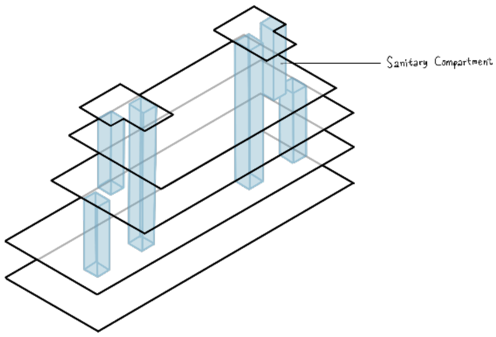
Power Supply

PV system: Solar Ivy will be implemented as alternative renewable energy within the design. An average of 500 Solar Ivy leaves are recommended for one residential, which could generate about 250 watts. The excess energy produced will be stored in the batteries in the plant room, which can later be used for emergency or nocturnal use

Electricity



Hydraulic System



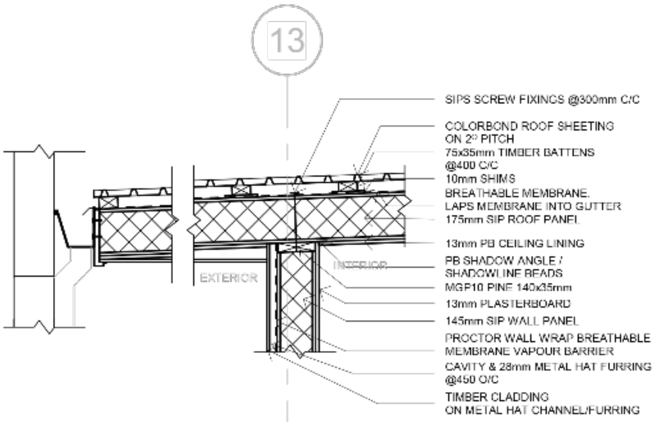
Sanitary Compartments

The design will collect rainwater which will be used for flushing toilets and watering the vertical community garden. Grey water will be collected within the building, and after being treated, the water will be re-used for flushing the toilet and watering the vertical community garden.

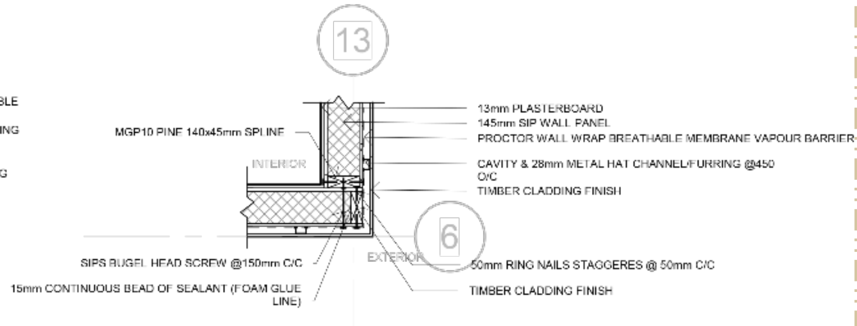
Sanitary Compartments on each level are positioned to align to make the plumbing connection to the bathrooms in each module possible.

APPENDIX A

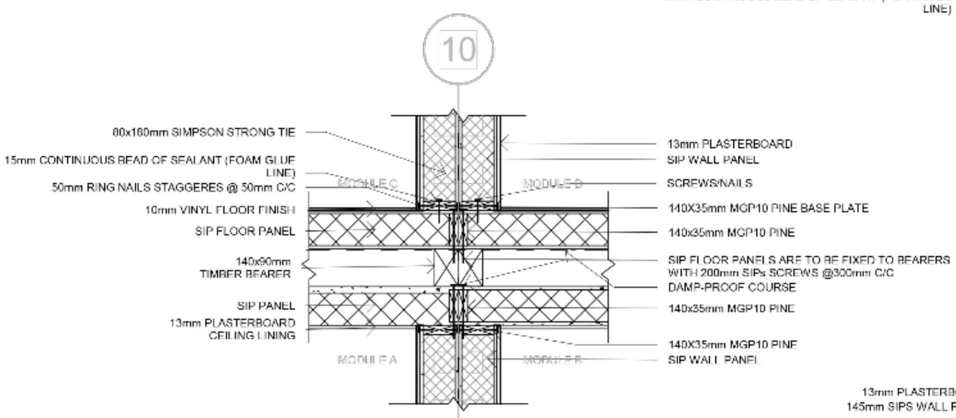
MATERIAL SELECTION: DETAILS



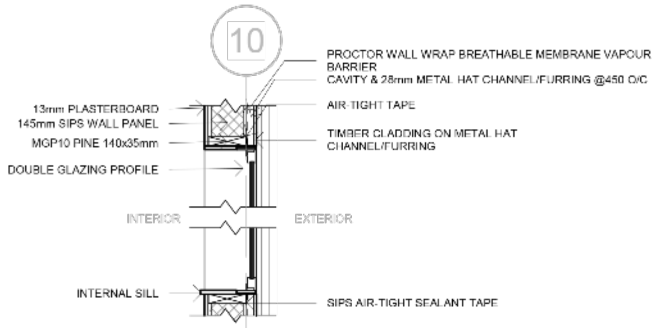
Roof-wall Detail
1:20



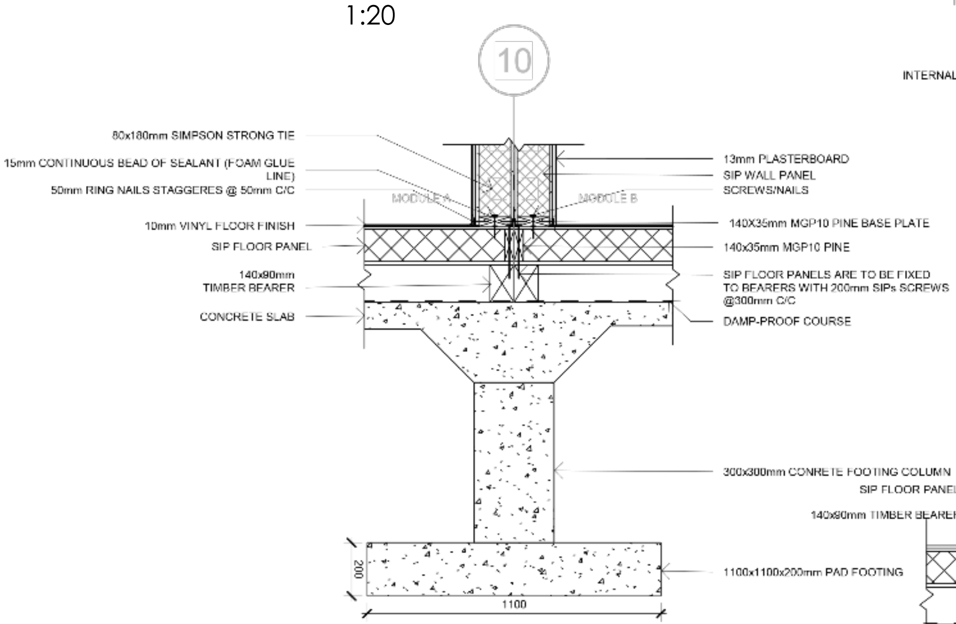
Wall Corner Detail
1:20



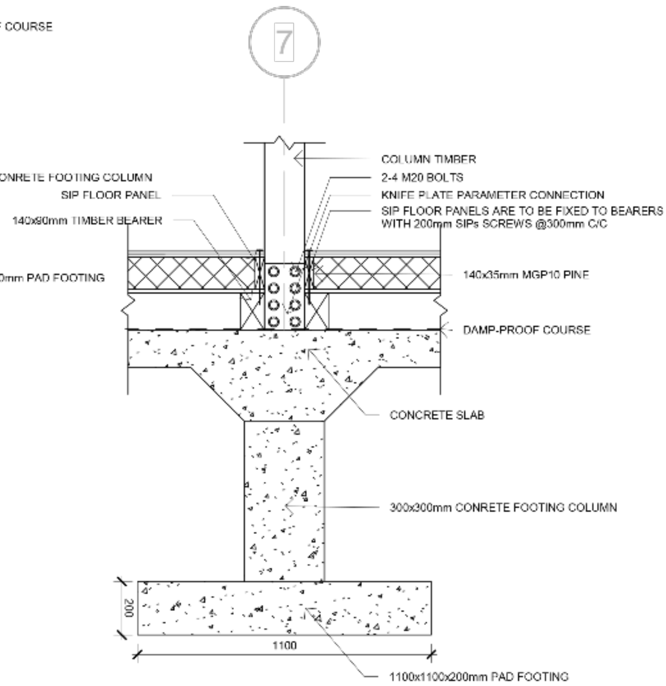
Module-to-module Connection
(Vertical & Horizontal)
1:20



Window-wall Detail
1:20



Footing-to-module Connection
1:20



Footing-to-middle Columns Connection
1:20

The flexural strength, shear, and the bearing capacity of the bearer will be checked. The material of bearer is Timber F17 140*90mm Seasoned Jarrah (SD4).

For column, MGP10 140*45*2 (Double Stud according to SIPs Industries specification) will be used and check for tension capacity, compression capacity, deflection, moment capacity, shear capacity and combined bending and compression check.

Wind Action

	Cfig	Serviceability	Ultimate
Windward Wall	0.56	326.028 Pa	482.379 Pa
Leeward Wall	-0.4	-232.877 Pa	-344.557 Pa
Side Wall	-0.52	-302.741 Pa	-447.923 Pa
Roof	-1.04	-605.481 Pa	-895.847 Pa

Wind Action – *(All data was taken from AS1170.0 and AS1170.2)*

Given conditions (from assignment brief):

- Site wind category = 3
- Design life = 50
- Importance level = 2

Design Wind Speed, Vdes, ϴ

$$Vdes,\theta = Vsit,\theta$$

$$Vsit,\theta = VRMd(Mz,catMsMt)$$

Regional Wind Speed, VR (Ultimate)

➢ Medium risk for life losses; structure importance level = 2

➢ Location: Perth, Australia:

- From wind map Australia, Perth is located at Region A4 (Non- Cyclonic region)

➢ Design life span = 50 years; Probability of exceedance: 1/500

➢ Regional Wind Speed, VR = 45m/s

Shielding Multiplier, Ms

➢ Assuming no building around, Ms= 1.0

<u>Design Wind Speed</u>

$$Vsit,\theta\ (Ultimate) = VRMd(Mz,catMsMt)$$
$$= 45 \times 1.0(0.842 \times 1.0 \times 1.0) \quad = 37.89 \text{ m/s}$$

$$Vsit,\theta\ (Serviceability) = VRMd(Mz,catMsMt)$$
$$= 37 \times 1.0(0.842 \times 1.0 \times 1.0) \quad = 31.15 \text{ m/s}$$

Design Wind Pressure

$$\rho = (0.5\rho air)[Vdes,\theta]^2 Cfig\ Cdyn$$

Regional Wind Speed, VR (Serviceability)

➢ Medium risk for life losses; structure importance level = 2

➢ Location: Perth, Australia:

- Region A4 (Non- Cyclonic region)

➢ Design life span = 50 years; Probability of exceedance: 1/25

➢ Regional Wind Speed, VR = 37m/s

Wind Directional Multipliers, Md

➢ For Region A4:

- Md= 1.0; Assume any wind direction as critical wind direction is unknown.

Terrain /Height Multiplier, Mz,cat

➢ From google map, Terrain category classified as 3 (TC3)

➢ Height of structure, $z = 12m$

- Mz,cat = 0.842 (linear interpolation)

Topographic Multiplier, Mt

➢ Assuming flat terrain, Mt= 1.0

Assumption on Critical Wind Direction

Assuming wind direction is coming from all direction used in the calculation for wind load.

Aerodynamic Shape Factor, Cfig

Internal Pressure

Largest opening area (window) = $1.83 \times 2.134 = 3.9m^2$

Total area-corresponding wall = $10 \times 3 = 30m^2$

Opening percentage= 0.13%

One wall permeable, windward wall impermeable; $Cp,i = -0.3$ [AS1170.2, Table 5.1(A)]

4 effective surface, $Kc,i = 0.8$ [AS1170.2, Table 5.5]

$$Cfig,i = Cp,i \times Kc,i = -0.3 \times 0.8 = -0.24$$

External Pressure

$$Cfig,e = Cp,e \times Ka \times Kc,e \times Kl \times Kp$$

$h = z = 12m\,;\ \leq 25m\ (building\ on\ ground)\,;Cp,e = 0.7$ [AS1170.2, Table 5.2(A)]

$b = 15m\,, d = 10m\,; \frac{d}{b} = \frac{10}{15} = 0.67 \ \ \leq 1;\ Cp,e = -0.5$ [AS1170.2, Table 5.2(B)]

$Both\ side\ wall, Cp,e = \ -0.65\ (most\ critical)$ [AS1170.2, Table 5.3(C)]

$Roof\ , h = 12m\,, d = 10m\,; \frac{h}{d} = \frac{12}{10} = 1.2\ \geq 1.0\,; Cp,e = -1.3$ [AS1170.2, Table 5.3(A)]

$Assume\ Tributary\ area \leq 10\,; Ka = 1.0$ [AS1170.2, Table 5.4]

4 effective surface, $Kc,e = 0.8$ [AS1170.2, Table 5.5]

$$Kl = 1.0\,; Kp = 1.0$$

Design Wind Pressure

$$\rho = (0.5\rho air)[Vdes,\theta]^2 Cfig\ Cdyn$$

$\rho = (0.5 \times 1.2)[37.89]^2 \times -0.24 \times 1.0 = -206.73\ Pa\ (Ultimate)$

$\rho = (0.5 \times 1.2)[31.15]^2 \times -0.24 \times 1.0 = -139.73\ Pa\ (Serviceability)$

SpaceGass Analysis

	For Beams	For Columns
Maximum Shear Force	12.91kN	0.96 kN
Maximum Bending Moment	5.8 kNm	0.6 kNm
Maximum Axial Force	2.13 kN	21.01 kN
Maximum Deflection	3.33 mm	8.89 mm

Beam

Flexural Strength (Moment Capacity)

Design flexural strength, $M^* = \mathbf{5.8\ kNm}$

$Md = \phi k1k4k6k9k12f_b{}'Z$

F17 Grade of Timber

ϕ	0.85
Duration of load= 50 years, k_1	0.57
Seasoned timber, Assume moisture content <15%, k_4	1.0
Assume covered timber structure, k_6	1.0
Combined & discrete parallel system, $ncom$	2
Combined & discrete parallel system, $nmem$	9
Table 2.7, $g31$	1.14
Table 2.7, $g32$	1.33

Sub values into equation, $k_9 = g_{31} + (g_{32} - g_{31})(1 - 2s/L)$ where s = 1.2m (spacing between bearer & L=10m effective span)

$\mathbf{k_9 = 1.2844}$

-For beam bending about its major axis & having continuous lateral restraint, $S_1 = 0$ and hence, $k_{12} = 1.0$

-For F17 grade of timber, $\mathbf{f' = 42\ MPa = 42 * 10^3 kPa}$

Z= bd26= 90*14026 = $\mathbf{294000\ mm^3 = 0.294 * 10^{-3}\ m^3}$

-Subs all into the equation and we can find the flexural strength of the bearer, $\mathbf{Md = 7.68 kNm}$

-Since $\mathbf{Md > M^*}$, hence, flexural strength check = **OK**.

Shear Capacity

$Vd = \phi k1k4k6fsAs$

-Design shear, $V^* = \mathbf{12.91\ kN}$

F17 Grade of Timber

ϕ	0.85
Duration of load= 50 years, k_1	0.57
Seasoned timber, Assume moisture content <15%, k_4	1.0
Assume covered timber structure, k_6	1.0
f_s'	$3.6MPa$
A_s	8400mm^2
Table 2.7, $g31$	1.14
Table 2.7, $g32$	1.33

From Table H2.1, $f' = 3.6MPa$ = $\mathbf{3.6 * 10^3\ kPa}$

$A_s = \frac{2}{3}bd = \frac{2}{3} * 90 * 140 = 8400$mm^2 = **8.4 x 10^{-3} m^2**

Subs all value into the equation and get $\boldsymbol{Vd}$ = $\mathbf{14.65\ kN}$

Since $\boldsymbol{Vd > V^*}$, hence, shear capacity check = **OK**.

Bearing Capacity

$$Nd,p = \phi k_1 k_4 k_6\ k_7 f_p' A_p$$

Design bearing, $\boldsymbol{N^*}$ = $\mathbf{2.13\ kN}$

F17 Grade of Timber

ϕ	0.85
Duration of load= 50 years, k_1	0.57
Seasoned timber, Assume moisture content <15%, k_4	1.0
Assume covered timber structure, k_6	1.0
k_7	1.0
SD4, f_p'	17 MPa
Ap	19600 mm^2

Since the strength group for Jarrah is SD4, $\boldsymbol{f'}$ **=** $\mathbf{17 MPa = 17 * 10^3\ kPa}$

Since the maximum point load is transferred by the column, $\boldsymbol{Ap}$ **=** $\boldsymbol{Area\ of\ column}$ **= 140 * 90 =19600** $\boldsymbol{mm^2}$ **=** $\mathbf{19.6 * 10^{-3}}$ $\boldsymbol{m^2}$

Subs all value into the equation and get $\boldsymbol{Nd,p}$ = $\mathbf{161.44\ kN}$

Since $\boldsymbol{Nd,p > N^*}$, bearing capacity check = **OK**

Deflection Check

Since there are 2 different lengths of bearer in this design, deflection check is done for both.

Maximum deflection allowed for a floor bearer (beam) would be span/300 <Table C1 AS1170.0>.

(a) Bearer with 3.5mm Length Max. deflection allowed = 3500/300 = 9.67mm Max. deflection in design = 3.33mm Since max. deflection allowed > max. deflection in design, deflection check = OK,	(b) Bearer with 3m length Max. deflection allowed = 3000/300 = 10mm Max. deflection in design = 4.14mm Since max. deflection allowed > max. deflection in design, deflection check = OK

Column

Tension capacity

AS 1720.1 Table<H 3.1>, For MGP 10 stress grade,

Tension parallel to grain, f'c	7.7 MPa
At	0.0063 m^2
Capacity factor ϕ	0.7
AS 1720.1	
Clause 2.4.1.1, k1 = 1	1.0
Clause 2.4.2, k4 = 1.15	1.0
Clause 2.4.3, k6 = 1	17 MPa
Ap	19600 mm^2

AS 1748, At = 140mm x 35mm = 0.0063 m^2 (no holes)

AS 1720.1 Table< 2.1>, Capacity factor, Φ = 0.7

Therefore, Nd,t = Φ k1 k4 k6 f'tAt

= (0.7)(1)(1.15)(1)(7700)(0.0063)

Compression capacity:

AS 1720.1 Table<H 3.1>, For MGP 10 stress grade,

Compression parallel to grain, f'c	18 MPa
Ac	0.0063 m^2
Capacity factor ϕ	0.7
AS 1720.1	
Clause 2.4.1.1, k1 = 1	1.0
Clause 2.4.2, k4 = 1.15	1.0
Clause 2.4.3, k6 = 1	17 MPa
Clause 3.3.3, ρc	0.96

AS 1748, Ac = 140mm x 45mm
= 0.0063 m^2 (no holes)
For major axis, S3 = g13L/d(where g13 = 0.7, L= 3m) **= 15**

AS 1720.1 Clause 3.3.3,
Stability factor, ρc S3 = 0.96(15) = 14.4 (major)
ρc S4 = 0.96(47) **=45.1 (minor)**

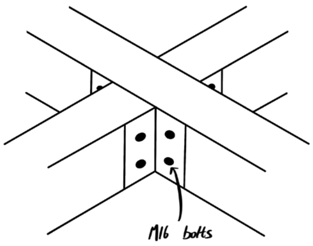
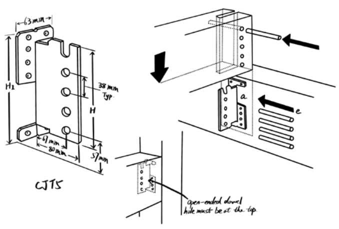
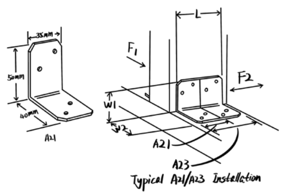
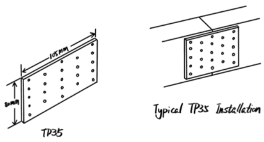
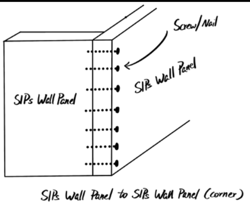
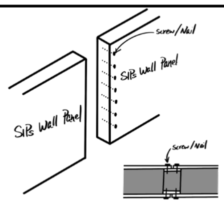
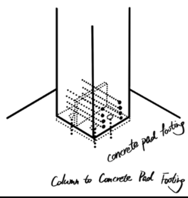
For 10≤ ρc S3 ≤20, K = 1.5 -0.05 ρc S3
= 0.78

For ρc S4 ≥20, K = 200/(ρc S4)^2
= 0.098

Strength limit state capacity, Clause 3.3.1.1,
Major axis, Nd,c = Φ K1K4 K6 K12f'c Ac = 45.16 kN > N*c = **32.62 kN** Compression check = OK.

Deflection Check:
Maximum Deflection allowed = Span/500
= 3000/500
= 6mm
Maximum Deflection in Design= 1.15mm
Since maximum deflection allowed > maximum deflection in design, deflection check = OK

Connection

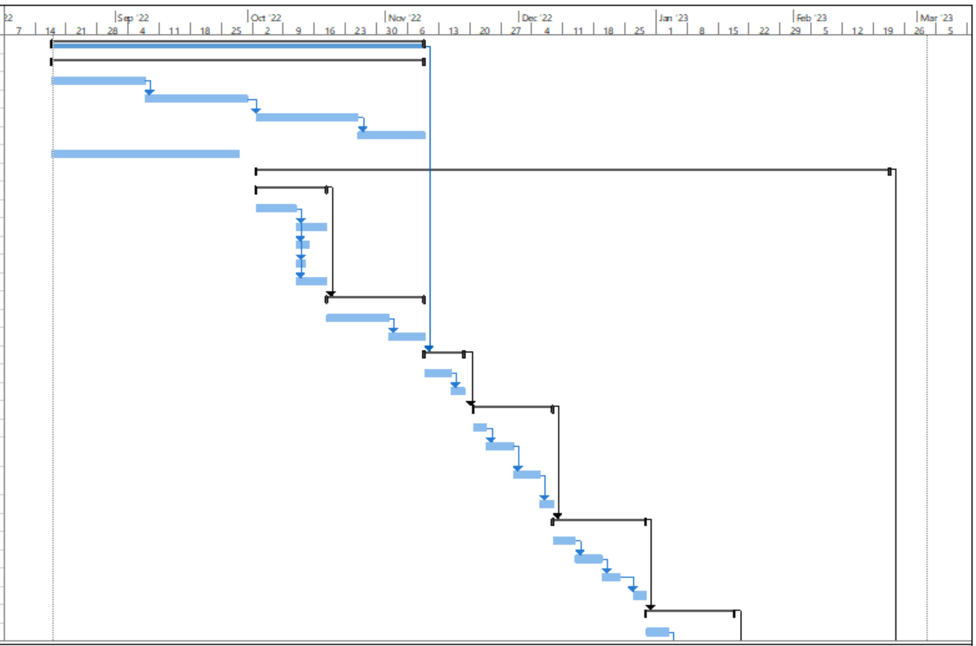
Bearer-to-bearer (Intermediate)	Bearer-to-bearer (End and End Corner)	Bearer-to-column	Column-to-column (Module-module)
			
M16 bolts No. of bolts = 8 pcs Minimum spacing $End\ dssstance = 5D = 5 \times 16 = 80mm$ $Edge\ dssstance = 4D = 4 \times 16 = 64mm$	Simpson Strong Tie – CJT3S	Simpson Strong Tie – A21	Simpson Strong Tie – TP37 Dimension – 80W x 180L
SIP wall panel to SIP wall panel	SIP wall panel to SIP wall panel to spline	Column to Footing	
			
Shank diameter – 4.8mm Minimum spacing between nails - 150 mm c/c spacing minimum	Shank diameter – 4.8mm Minimum spacing between nails - 150 mm c/c spacing minimum	M20 bolts No. of bolts = 8 pcs	

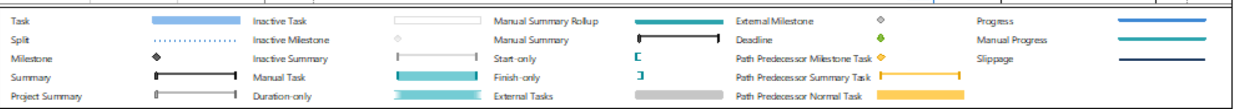
APPENDIX C

PROJECT & CONSTRUCTION TIMELINE

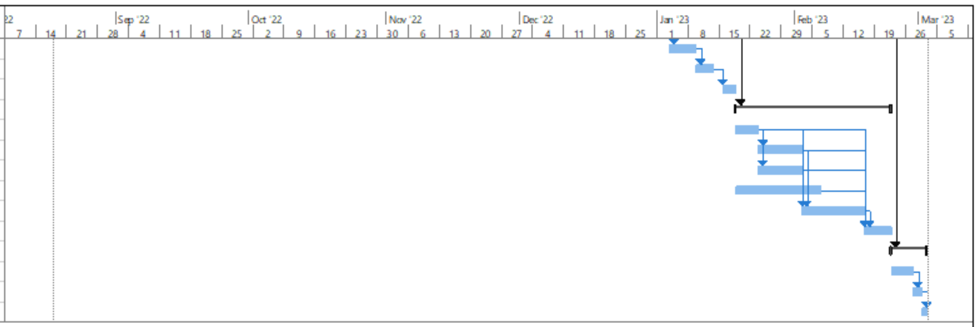
Gantt Chart

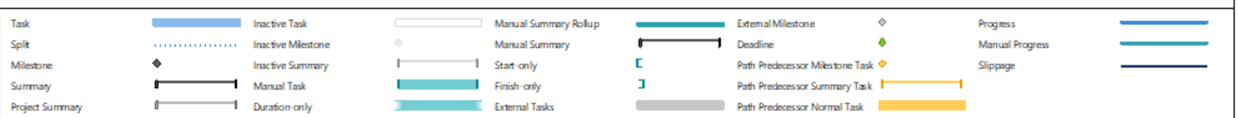
ID	Task Name	Start	Finish
1	**A. Prefabrication**	**Thu 18/8/22**	**Wed 9/11/22**
2	Module	Thu 18/8/22	Wed 9/11/22
3	Structural frame (all module)	Thu 18/8/22	Wed 7/9/22
4	SIPs floor panel (all module)	Thu 8/9/22	Fri 30/9/22
5	SIPs wall panel (all module)	Mon 3/10/22	Tue 25/10/22
6	Partition (internal & external)	Wed 26/10/22	Wed 9/11/22
7	Staircase	Thu 18/8/22	Wed 28/9/22
8	**B. Construction phase**	**Mon 3/10/22**	**Wed 22/2/23**
9	Site preperation	Mon 3/10/22	Tue 18/10/22
10	Site clearing	Mon 3/10/22	Tue 11/10/22
11	Temporary site office	Wed 12/10/22	Tue 18/10/22
12	Temporary security fencing	Wed 12/10/22	Fri 14/10/22
13	Temporary water closet (WC)	Wed 12/10/22	Thu 13/10/22
14	Water and electrical supplies	Wed 12/10/22	Tue 18/10/22
15	Foundation and footing	Wed 19/10/22	Wed 9/11/22
16	Formwork and rebar installation	Wed 19/10/22	Tue 1/11/22
17	Concrete casting	Wed 2/11/22	Wed 9/11/22
18	Module installation for ground floor	Thu 10/11/22	Fri 18/11/22
19	Connection to footing	Thu 10/11/22	Tue 15/11/22
20	Connection to first floor	Wed 16/11/22	Fri 18/11/22
21	Module installation for first floor	Mon 21/11/22	Thu 8/12/22
22	Connection to second floor	Mon 21/11/22	Wed 23/11/22
23	Bearer installation (Corridor & walkways)	Thu 24/11/22	Tue 29/11/22
24	SIPs floor panel installation (Corridor & walkways)	Wed 30/11/22	Mon 5/12/22
25	Staircase installation (GF-1F)	Tue 6/12/22	Thu 8/12/22
26	Module installation for second floor	Fri 9/12/22	Thu 29/12/22
27	Connection to third floor	Fri 9/12/22	Tue 13/12/22
28	Bearer installation (Corridor & walkway	Wed 14/12/22	Mon 19/12/22
29	SIPs floor panel installation (Corridor &	Tue 20/12/22	Fri 23/12/22
30	Staircase installation (1F-2F)	Tue 27/12/22	Thu 29/12/22
31	Module installation for third floor	Fri 30/12/22	Wed 18/1/23
32	SIPs roof panel installation	Fri 30/12/22	Tue 3/1/23





ID	Task Name	Start	Finish
33	Bearer installation (Corridor & walkway	Wed 4/1/23	Mon 9/1/23
34	SIPs floor panel installation (Corridor &	Tue 10/1/23	Fri 13/1/23
35	Staircase installation (2F-3F)	Mon 16/1/23	Wed 18/1/23
36	Other installation	Thu 19/1/23	Wed 22/2/23
37	Door and window installation	Thu 19/1/23	Mon 23/1/23
38	Floor finishing	Tue 24/1/23	Thu 2/2/23
39	Wall finishing	Tue 24/1/23	Thu 2/2/23
40	Piping installation	Thu 19/1/23	Mon 6/2/23
41	Utilities installation	Fri 3/2/23	Thu 16/2/23
42	Moving furniture	Fri 17/2/23	Wed 22/2/23
43	**C. Project completion**	**Thu 23/2/23**	**Thu 2/3/23**
44	Site cleaning (Housekeeping)	Thu 23/2/23	Mon 27/2/23
45	Final inspection	Tue 28/2/23	Wed 1/3/23
46	Handover	Thu 2/3/23	Thu 2/3/23





APPENDIX C

PROJECT & CONSTRUCTION TIMELINE

Project Timeline

A.	Prefabrication	60	-
A1	Module	60	-
A1.1	Structural frame	3	-
A1.2	SIPs floor panel	4	A1.1
A1.3	SIPs wall panel	4	A1.2
A1.4	Partition (internal & external)	2	A1.3
A1.5	Repeat	60	A1.1 , A1.2 , A1.3 , A1.4
A2	Staircase	30	-
B.	Construction phase	107	-
B1	Site preparation	12	-
B1.1	Site clearing	7	-
B1.2	Temporary site office	5	B1.1
B1.3	Temporary security fencing	3	B1.1
B1.4	Temporary water closet (WC)	2	B1.1
B1.5	Water and electrical supplies	5	B1.1
B2	Foundation and footing	16	B1
B2.1	Formwork and rebar installation	10	-
B2.2	Concrete casting	6	B2.1
B3	Module installation for ground floor	7	A1, B2
B3.1	Connection to footing	4	-
B3.2	Connection to first floor	3	B3.1
B4	Module installation for first floor	14	A1, A2, B3
B4.1	Connection to second floor	3	-
B4.2	Bearer installation (Corridor & walkways)	4	B4.1
B4.3	SIPs floor panel installation (Corridor & walkways)	4	B4.2
B4.4	Staircase installation (GF-1F)	3	B4.3
B5	Module installation for second floor	14	B4
B5.1	Connection to third floor	3	-
B5.2	Bearer installation (Corridor & walkways)	4	B5.1
B5.3	SIPs floor panel installation (Corridor & walkways)	4	B5.2
B5.4	Staircase installation (1F-2F)	3	B5.3
B6	Module installation for third floor	14	B5
B6.1	SIPs roof panel installation	3	-
B6.2	Bearer installation (Corridor & walkways)	4	B6.1
B6.3	SIPs floor panel installation (Corridor & walkways)	4	B6.2
B6.4	Staircase installation (2F-3F)	3	B6.3
B7	Other installation	30	B6
B7.1	Door and window installation	3	B6.1
B7.2	Piping installation	12	B6.3
B7.3	Floor finishing	7	B7.1
B7.4	Wall finishing	7	B7.3
B7.5	Utilities installation	7	B7.4
B7.6	Moving furniture	4	B7.1 , B7.2, B7.3 , B7.4 , B7.5
C.	Project completion	6	-
C1	Site cleaning (Housekeeping)	3	C7.6
C2	Final inspection	2	C7.6
C3	Handover	1	C1, C2

APPENDIX D
COSTING

Bill of Quantities

This section of the report will calculate the detailed cost of the proposed building. The table below will calculate a detailed bill of quantities (BQ) based on the engineering analysis which contains the computed quantity take-off. The unit rates of each construction item will be based on Rawlinsons Construction Cost Guide 2022 (2022) while for SIP Panels pricing will be based on Specifier.

	Item Description	Unit	Quantity	Rate ($/Rate)	Total Amount ($)
Class A	General Item				
A311	Offices				
	Site Office with insulated panel construction 3600x2400mm	Week	21	60.00	1,260.00
A314	Stores				
	Storage Sheds 3000 x 2400mm	Week	21	45.00	945.00
A315	Canteens and messrooms				
	Lunchroom Insulated panel Construction 3600 x 2400mm	Week	21	60.00	1,260.00
A331	Cranes				
	Hoisting mobile crane 50 tonne	hour	1600	230.00	368,000.00
A361	Access scaffolding				
	Mobile Scaffolds: 1.8x1.2x4 high	Week	39	210.00	8,190.00
A371	Supervision				
	Site Engineer	Year	0.8	97,778.00	78,222.40
A373	Labour teams				
	General labourer	hr	8430	69.75	587,992.50
	Plumber	hr	255	86.25	21,993.75
	Electrician	hr	255	89.00	22,695.00
	Mechanic	hr	255	77.00	19,635.00
Class D	Demolition and Site Clearance				
D11	General clearance				
	Site preparation light vegetation x 500sqm	sqm	2000	0.45	900.00
Class E	Earthwork				
	Excavation for foundations				
E313	Excavate over site to reduce levels x200cum	cum	850	15.95	13,557.50
Class F	In situ concrete				
	Bases, footings, pile caps and ground slabs 300-500mm				
F723	Column foundation (pad footing) 20MPa	cum	16.32	274.00	4,471.68
	Add extra concrete strength to 32MPa	cum	16.32	13.20	215.42
Class G	Concrete Ancillaries				
	Plain round steel bars				
G515	Tempcore, deformed bar reinforcement - Y12	t	5	3,225.00	16,125.00
Class M	Structural Metalwork				
	Frabrication of members for frames- Portal frames				
M353	Black steel- Square hollow sections up to 100 x 100mm	t	10	10,200.00	102,000.00
	Bolts 16-20mm				
M632	Black steel bolts-16mm x100mm	no	75	0.95	71.25
Class O	Timber				
	Hardwood components				
O124	F17 Jarrah (assume 150 x 75mm)	m	675	41.97	28,329.75
O113	MGP10 (assume 150x38mm)	m	675	7.10	4,792.50
	Fittings and fastenings				
O52	Stainless steel nails: 50mm x 10 (290 per kg)				
	assume each module uses same amount of nails	kg	60	85.00	5,100.00
O53	Coachscrews: 10mm x 50mm	no	1200	6.55	7,860.00
O54	Steel holding down bolt including setting in concrete: 16 x 300mm	no	160	30.90	4,944.00
O55	Timber connectors: Universal framing anchor	no	2400	2.73	6,552.00
Class V	Painting				
	Internal module painting				
V421	Prime, one sealer undercoat and two coats semi-gloss or gloss acrylic				
	General surfaces	sqm	2400	18.45	44,280.00
	External module painting				
	Prime, one sealer undercoat and two coats semi-gloss or gloss acrylic			18.45	
	General surface- 9m above ground	sqm	2400	2.10	49,320.00
Class Z	Simple building works incidental to civil engineering works				
	Flooring				
Z131	Timber decking, close spaced and fixed to timber				
	Pencil rounded 100x25mm - Treated pine	sqm	1200	102.50	123,000.00
	Insulation				
Z133	Marine plywood for paint fixed to timber framing				
	5mm thick	sqm	720	47.70	34,344.00
Z231	SIP Panels for flooring & roofing	sqm	1200	200.00	240,000.00
Z233	SIP Panels for walls	sqm	720	200.00	144,000.00
	Windows				
Z311	Aluminium windows- Domestic standard				
	Awning 25% opening	sqm	108	326.00	35,208.00
	Timber door				-
Z313	Solid Core: Standard solid core flush door size 2040x820x35mm				-
	Plywood for paint finish on both sides	no	24	358.00	8,592.00
	Suspended ceilings				
Z455	Flush ceiling with a concealed suspension system				
	Fire rated plasterboard- 2x13mm thick (one hour)	sqm	600	118.50	71,100.00
	Tiles				
	Mosaic - Nonslip				
Z421	Homogeneous tiling, 50x50mm in sheets	sqm	24	116.00	2,784.00
	Gross Cost ($)				2,057,740.75
	Add: 10% Profit				205,774.08
	10% GST				205,774.08
	5% Overheads				102,887.04
	TOTAL AMOUNT ($)				2,572,175.94

APPENDIX D

COSTING

Cost & Time Relationship

PROJECT TASK	TOTAl AMOUNT	WEEKLY COST	START DATE	END DATE	DURATION	1	2	3	4
Module Prefabrication C1	$ 65,495.26	$ 7,277.25	WEEK_1	WEEK_9	9	$ 7,277.25	$ 7,277.25	$ 7,277.25	$ 7,277.25
Staircase Prefabrication C2	$ 6,477.68	$ 1,619.42	WEEK_1	WEEK_4	4	$ 1,619.42	$ 1,619.42	$ 1,619.42	$ 1,619.42
Site Preparation D1	$ 22,403.13	$ 11,201.56	WEEK_5	WEEK_6	2				
Foundation and footing D2	$ 26,015.13	$ 13,007.56	WEEK_7	WEEK_8	2				
Module installation for ground floor D3	$ 29,250.00	$ 29,250.00	WEEK_9	WEEK_9	1				
Module installation for first floor D4	$ 29,250.00	$ 14,625.00	WEEK_10	WEEK_11	2				
Module installation for second floor D5	$ 29,250.00	$ 14,625.00	WEEK_12	WEEK_13	2				
Module installation for third floor D6	$ 29,250.00	$ 14,625.00	WEEK_14	WEEK_15	2				
Other installation D7	$ 951,374.06	$ 237,843.52	WEEK_16	WEEK_19	4				
Plant and Salary	$ 1,383,410.81	$ 72,811.10	WEEK_1	WEEK_19	19	$ 72,811.10	$ 72,811.10	$ 72,811.10	$ 72,811.10
Total amount	**$ 2,572,176.06**	$ 416,885.41							
Total weekly cost =						$ 81,707.77	$ 81,707.77	$ 81,707.77	$ 81,707.77
Cummulative cost						$ 81,707.77	$ 163,415.53	$ 245,123.30	$ 326,831.06
Progress income included profit=			assuming profit margin of 10%						359514.1683
10 % retention									$ 35,951.42
Progress payment									$ 323,562.75
Cummulative progress payment						0	0	0	$ 323,562.75

	5	6	7	8	9	10	11	12	13	14
	$ 7,277.25	$ 7,277.25	$ 7,277.25	$ 7,277.25	$ 7,277.25					
	$ 11,201.56	$ 11,201.56								
			$ 13,007.56	$ 13,007.56						
					$ 29,250.00					
						$ 14,625.00	$ 14,625.00			
								$ 14,625.00	$ 14,625.00	
										$ 14,625.00
	$ 72,811.10	$ 72,811.10	$ 72,811.10	$ 72,811.10	$ 72,811.10	$ 72,811.10	$ 72,811.10	$ 72,811.10	$ 72,811.10	$ 72,811.10
	$ 91,289.91	$ 91,289.91	$ 93,095.91	$ 93,095.91	$ 109,338.35	$ 87,436.10	$ 87,436.10	$ 87,436.10	$ 87,436.10	$ 87,436.10
	$ 418,120.97	$ 509,410.88	$ 602,506.79	$ 695,602.70	$ 804,941.05	$ 892,377.14	$ 979,813.24	$ 1,067,249.33	$ 1,154,685.43	$ 1,242,121.52
				405648.8008				408811.2963		
				$ 40,564.88				$ 40,881.13		
				$ 365,083.92				$ 367,930.17		
	$ 323,562.75	$ 323,562.75	$ 323,562.75	$ 688,646.67	$ 688,646.67	$ 688,646.67	$ 688,646.67	$ 1,056,576.84	$ 1,056,576.84	$ 1,056,576.84

15	16	17	18	19
$ 14,625.00				
	$ 237,843.52	$ 237,843.52	$ 237,843.52	$ 237,843.52
$ 72,811.10	$ 72,811.10	$ 72,811.10	$ 72,811.10	$ 72,811.10
$ 87,436.10	$ 310,654.61	$ 310,654.61	$ 310,654.61	$ 310,654.61
$ 1,329,557.62	$ 1,640,212.23	$ 1,950,866.84	$ 2,261,521.45	$ 2,572,176.06
	630259.1869			
	$ 63,025.92			
	$ 567,233.27			
$ 1,056,576.84	$ 1,623,810.11	$ 1,623,810.11	$ 1,623,810.11	$ 1,623,810.11

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