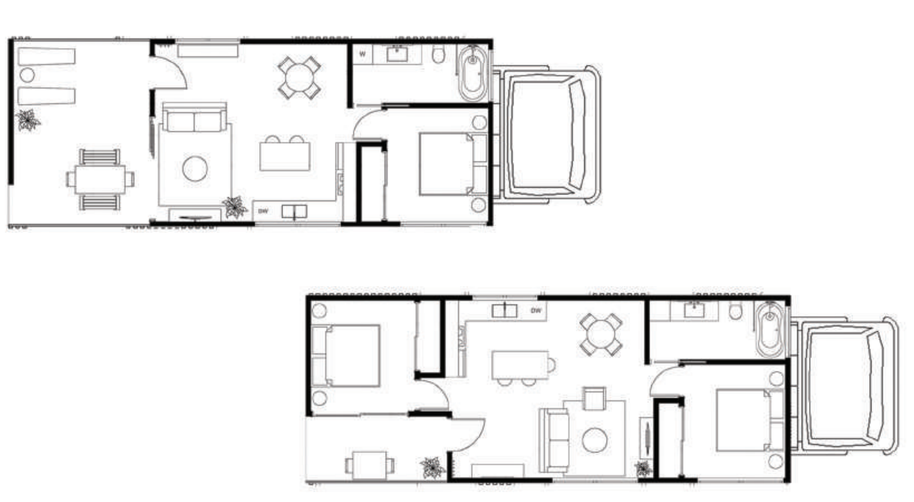
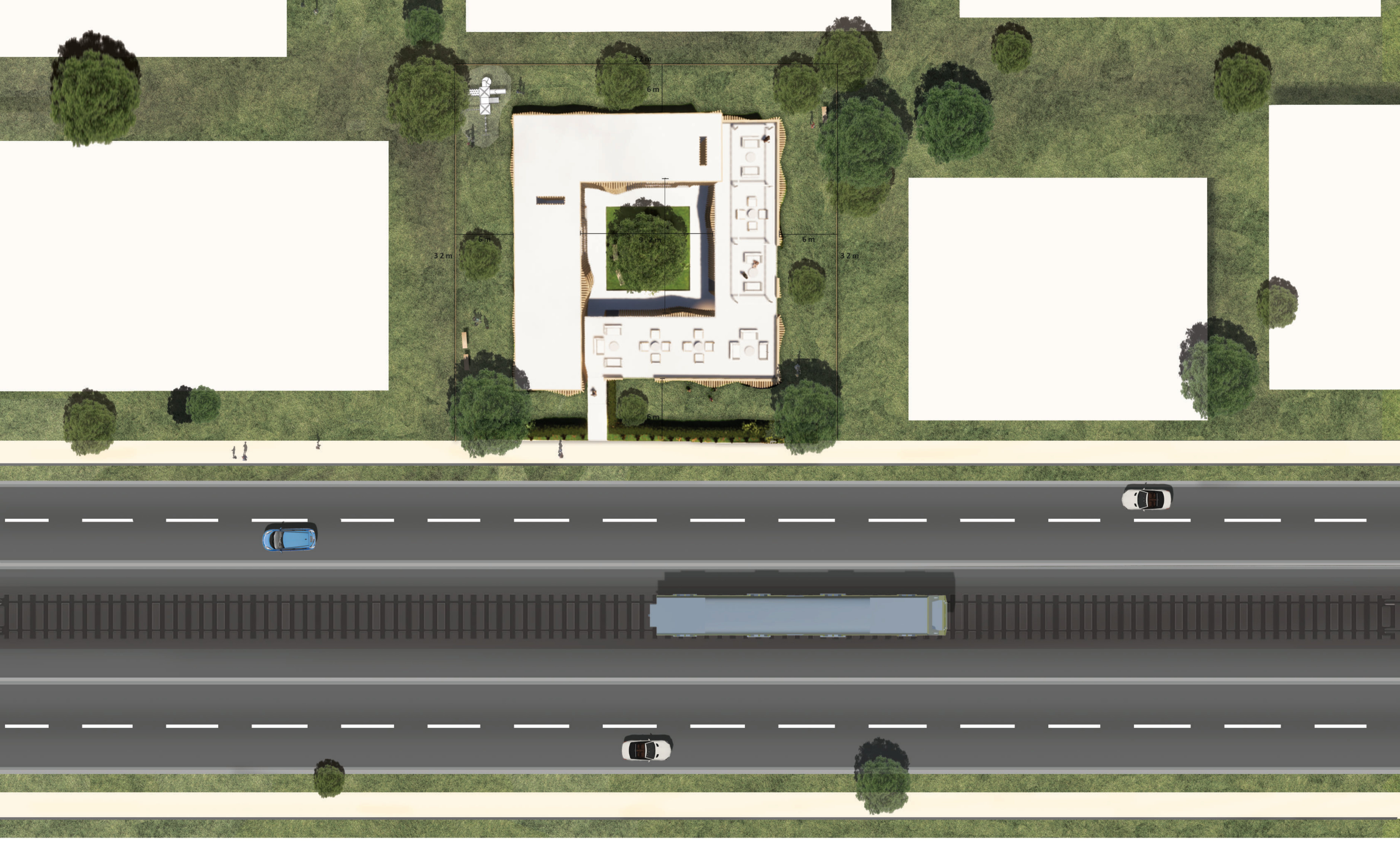


ABOUT THE DESIGN:

DESIGNED TO BE AFFORDABLE, MOVABLE AND ADAPTABLE, THIS SOCIAL HOUSING SCHEME FOCUSED ON SIMPLE BUT EFFECTIVE FLOOR PLANS AND ADAPTABLE FACADES TO CREATE ARCHITECTURE THAT CAN BE PLACED ANYWHERE. DESIGNED TO FIT PERFECTLY ONTO ONE TRANSPORT TRUCK, THE MODULE DESIGN CONSISTS OF ONE UNIT ENTIRELY PRE-FABRICATED THAT CAN BE HAULED AND PLACED ON SITE WITH VERY LITTLE CONSTRUCTION. THE FACADE SYSTEM HAS BEEN DEVELOPED WITH ATTACHABLE WINDOW SHADING BATTENS WHICH FLOW WITH THE BUILDINGS CLADDING SYSTEM. THE WINDOW SHADING SYSTEM CONSISTS OF DIFFERENT SIZED BATTENS THAT ARE CHOSEN DEPENDING ON THE SITES LATITUDE AND LONGITUDE TO ENSURE THE SHADING IS PERFECT FOR ANY LOCATION. THE CLADDING CREATES A GREAT FEATURE TO THE DESIGN AS IT CURVES AROUND WINDOWS AND BACK IN TO HUG THE EXTERIOR MODULE STRUCTURE. THE FACADE SYSTEM ALSO HAS ADDITIONAL ACOUSTIC PROTECTION IN ADDITION TO THE MODULES SIPS WALL PANELS TO HELP REDUCE CITY NOISE. EACH MODULE FOLLOWS THE SAME SIMPLE YET EFFICIENT DESIGN TO ALLOW BATHROOM SERVICES TO ALIGN AS WELL AS LOAD BEARING WALLS TO ENSURE ALL LOADS MEET THE GROUND. THIS DESIGNS CURRENT ORIENTATION WAS CHOSEN TO ALLOW OPTIMAL WINTER SUN TO ALL MODULES BUT THIS CAN BE ALTERED DEPENDING ON THE ORIENTATION AND SIZE OF NEW POTENTIAL LOCATIONS. OVERALL THIS DESIGN FOCUSED ON CREATING PERSONAL AND PRIVATE SPACES FOR RESIDENTS AS WELL AS PUBLIC COMMUNAL SPACES TO FORM A COMMUNITY WITHIN THE COMPLEX. THE COURTYARD DESIGN ALSO ALLOWS AN INTIMATE CIRCULATION SPACE TO ENCOURAGE INTERACTION WHILST BEING SEPERATE FROM THE STREET. LANDSCAPING ALLOWS A NATURAL BARRIER BETWEEN THE STREET AND GARDEN SPACES, BUT DEPENDING ON LOCATION THIS CAN BE ALTERED TO SUIT LOCAL FLORA AND WEATHER CONDITIONS



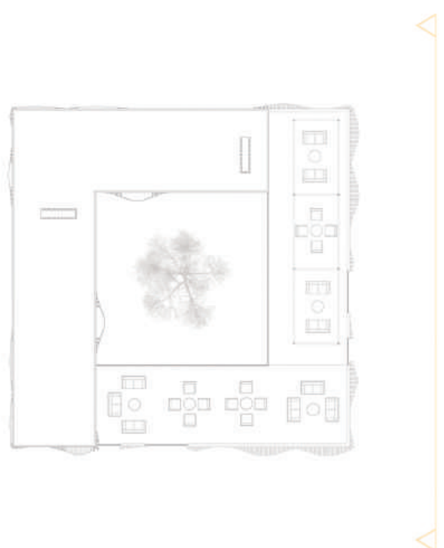
SITE PLAN
1:200

NESTLED INTO MELBOURNES INNER SUBURBS, THIS MODULAR PREFABRICATED COMPLEX CONSISTS OF 12 FLATS. THE SIMPLE DESIGN IS COST EFFECTIVE AND QUICK TO CONSTRUCT. THE SURROUNDING CONTEXT IS 2 AND 4 STOREY HIGH BUILDINGS AND THIS DESIGN TAKES ADVANTAGE OF THIS. WITH THE TOP STOREY TO THE REAR OF THE BLOCK PREVENTING OVERLOOKING ONTO THE PUBLIC BALCONY SPACE. THE NEIGHBOURING HOMES ARE 2 STOREYS BUT SHOULD NOT EXPERIENCE OVERSHADOING DUE TO 6M SETBACKS FROM THE SITE BOUNDARY IN ADDITION TO THE NEIGHOURING PROPERTIES AS PER THE BAYSWATER'S TOWN PLANNING SCHEME. THE MODULAR DESIGN IS 3 STOREYS HIGH AT ITS TALLEST POINT AND DOES NOT EXCEED 20M ABOVE THE GROUND LEVEL ON THE PRIMARY STREET FRONTAGE. BOUNDARY SETBACKS ARE 6M ON ALL EDGES AS IT IS SURROUNDED BY DEVELOPED LOTS. THIS CAN BE SHIFTED FORWARD TOO AS THE ZONING ALLOWS A NIL. SETBACK ON THE STREET FRONTAGE. THE ROOF CAN BE ANY STYLE TO MEET CHARACTER OF THIS ZONE, SO I HAVE OPTED FOR A PARAPET ROOF. THIS ALLOWS A MINIMAL DESIGN THAT ALLOWS THE TIMBER CLADDING TO RUN THE ENTIRE FACADE OF THE STRUCTURE. MINIMUM BALCONY DIMENSIONS ARE 2.5M, WHICH IS COMPLIANT WITH MY DESIGN AS WELL AS A COMMUNAL ROOFTOP BALCONY WHICH SPANS OVER 180 METRES SQUARED. AN EXTERNALLY ACCESSED STORAGE SPACE OF 4M2 PER RESIDENCE IS REQUIRED WHICH WILL BE ADDED TO SITE. COMMUNAL EXTERIOR CLOTHES DRYING AREAS WILL ALSO BE PROVIDED. IN ORDER TO MEET ALL TOWN PLANING SCHEMES.

NORTH ELEVATION

EAST ELEVATION

SOUTH ELEVATION



WEST ELEVATION

ELEVATIONS
1:100

GENERAL FLOOR PLANS
1:100

TWO BEDROOM MODULE

TWO BEDROOM SECTION
1:50

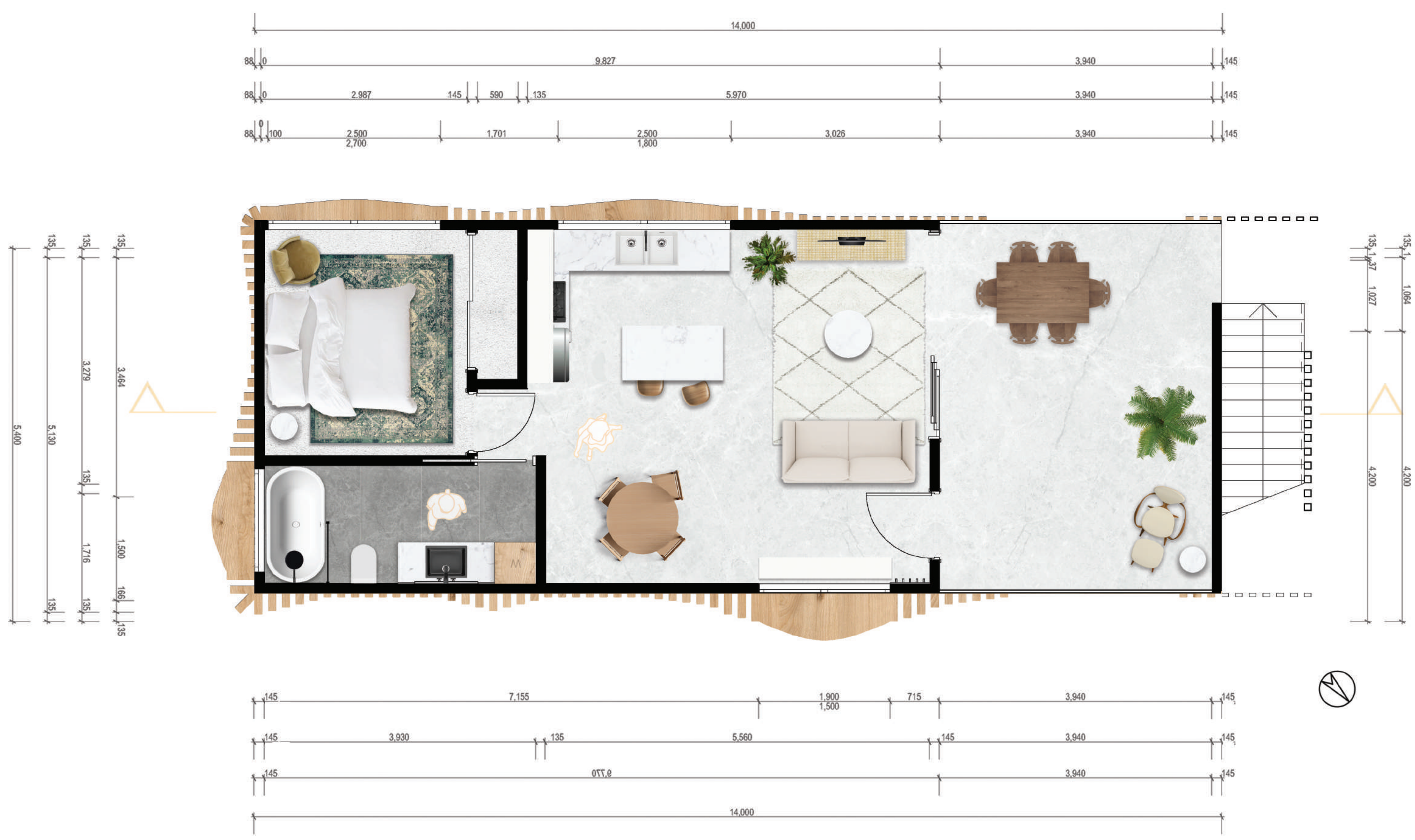
TWO BEDROOM FLOOR PLAN
1:50

TWO BEDROOM PLAN

THIS FLOOR PLAN IS 50M2 AND FITS PERFECTLY ONTO A TRANSPORT TRUCK IN ONE PIECE. THIS ALLOWS THE MODULE TO BE ALMOST ENTIRELY PRE-FABRICATED AND THEN ASSEMBLED ON-SITE. THE SUN SHADING FACADE SYSTEM IS ALSO PRE-FABRICATED TO SUIT THE MODULES GEOGRAPHICAL LOCATION AND THEN INSTALLED ON SITE. THE DESIGN FOCUSED ON BEING COST EFFECTIVE AND EASY TO ASSEMBLE BUT WITH SMART FLOOR PLANS AND A DYNAMIC FACADE SYSTEM THAT IS EFFECTIVE NO MATTER WHERE THE MODULES ARE PLACED. THE TWO BEDROOM MODULES ARE PLACED PREDOMINATELY ON THE GROUND PLANE SO THEY CAN UTILISE THE GARDEN SPACE SEEMING AS THEY HAVE A SMALLER BALCONY. THE UPPER FLOOR TWO BEDROOM MODULES HAVE A SHARED ROOF TERRACE THAT CAN BE UTILISED AS A GREEN ROOF, FOR EXERCISE, ROOFTOP MOVIES, ENTERTAINING AND MORE. THIS ALLOWS OPTIMAL USE OF SPACE AND ENCOURAGES COMMUNAL INTERACTIONS AND EVENTS.

ONE BEDROOM MODULE

ONE BEDROOM SECTION
1:50



ONE BEDROOM FLOOR PLAN
1:50

ONE BEDROOM PLAN

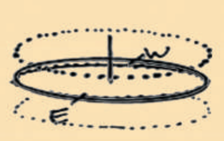
THIS FLOOR PLAN IS 50M2 AND FITS PERFECTLY ONTO A TRANSPORT TRUCK IN ONE PIECE. THIS ALLOWS THE MODULE TO BE ALMOST ENTIRELY PRE-FABRICATED AND THEN ASSEMBLED ON-SITE. THE SUN SHADING FACADE SYSTEM IS ALSO PRE-FABRICATED TO SUIT THE MODULES GEOGRAPHICAL LOCATION AND THEN INSTALLED ON SITE. THE DESIGN FOCUSED ON BEING COST EFFECTIVE AND EASY TO ASSEMBLE BUT WITH SMART FLOOR PLANS AND A DYNAMIC FACADE SYSTEM THAT IS EFFECTIVE NO MATTER WHERE THE MODULES ARE PLACED. THE ONE BEDROOM MODULES ARE PLACED PREDOMINATELY ON THE UPPER FLOORS AS THEY HAVE LARGE BALCONY SPACES. TO ALLOW MAJORITY OF SERVICES TO ALIGN AS WELL AS LOAD BEARING, THE LAYOUT IS IDENTICAL TO THE TWO BEDROOM MODULE, WITH THE THE SECOND BEDROOM BEING THE BALCONY SPACE. THE BALCONY SPACE IS LARGE ENOUGH TO ENTERTAIN, EXERCISE AND ANY OTHER NEDEDS IT MAY HAVE AND DUE TO ITS POSITIONING ALLOWS TWO VIEWS AS IT TUNNELS THROUGH THE APARTMENT DESIGN.

FACADE AND SHADING SYSTEM

TO ALLOW THIS PROJECT TO BE COMPLETELY SUITABLE TO NEW SETTINGS, THE SUN SHADING DEVICE MUST BE FLEXIBLE IN ORDER TO BE RELOCATED AT DIFFERENT LATITUDES. RELOCATING THE MODULES FROM PERTH TO DARWIN FOR EXAMPLE WILL REQUIRE DIFFERENT SUN SHADING PANELS FOR SUSTAINABLE AND EFFICIENT DESIGN.

NORTH POLE

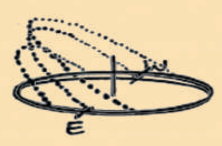
BRRR



24 HOUR DAY IN SUMMER
24 HOUR NIGHT IN WINTER

45 DEGREES NORTH

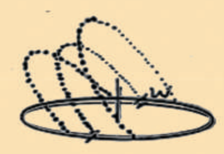
PORTLAND (USA), CANADA, VENICE (ITALY), BORDEAUX (FRANCE), SAPORO (JAPAN)



68.5 DEGREES IN SUMMER, 16 HOUR DAY
21.5 DEGREES IN WINTER, 8 HOUR DAY

32 DEGREES NORTH

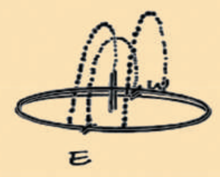
SAN DIEGO (USA), MARRAKECH, ALEXANDRIA, BAGHDAD, JERUSALEM



81.5 DEGREES IN SUMMER, 14 HOUR DAY
34.5 DEGREES IN WINTER, 10 HOUR DAY

EQUATOR

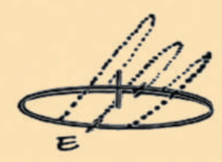
ECUADOR, INDONESIA, BRAZIL, MALDIVES, UGANDA, SOMALIA



66.5 DEGREES IN WINTER, 12 HOUR DAY
66.5 DEGREES IN SUMMER, 12 HOUR DAY

32 DEGREES SOUTH

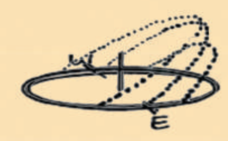
SYDNEY (AUSTRALIA), CAPETOWN (S. AFRICA), CHILE, MADAGASCAR



34.5 DEGREE DAY IN WINTER, 10 HOUR DAY
81.5 DEGREES IN SUMMER, 14 HOUR DAY

45 DEGREES SOUTH

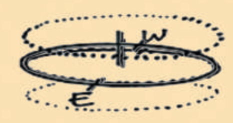
ARGENTINA, ATLANTIC OCEAN



21.5 DEGREES IN WINTER
21.5 DEGREES IN SUMMER, 16 HOUR DAY

SOUTH POLE

ANTARCTICA



24 HOUR NIGHT IN WINTER
24 HOUR DAY IN SUMMER

EAST & WEST

THE MEDIUM SIZED WINDOW COVERING WORKS PERFECTLY FOR EAST AND WEST FACING WINDOWS. IT CANNOT BE TOO LONG TO PREVENT WINTER SUN AND AS ITS ONLY MORNING AND EVENING SUN, HEAT GAIN IS NOT TOO EXCESSIVE IN SUMMER.

NORTH

DUE TO VARYING ANGLES OF INCIDENCE, EACH LONGITUDE REQUIRES DIFFERENT SIZED WINDOW COVERINGS.

NORTHERN HEMISPHERE REQUIRES SHALLOW COVERINGS AS IT WILL NEVER HAVE DIRECT SUN PENETRATION.

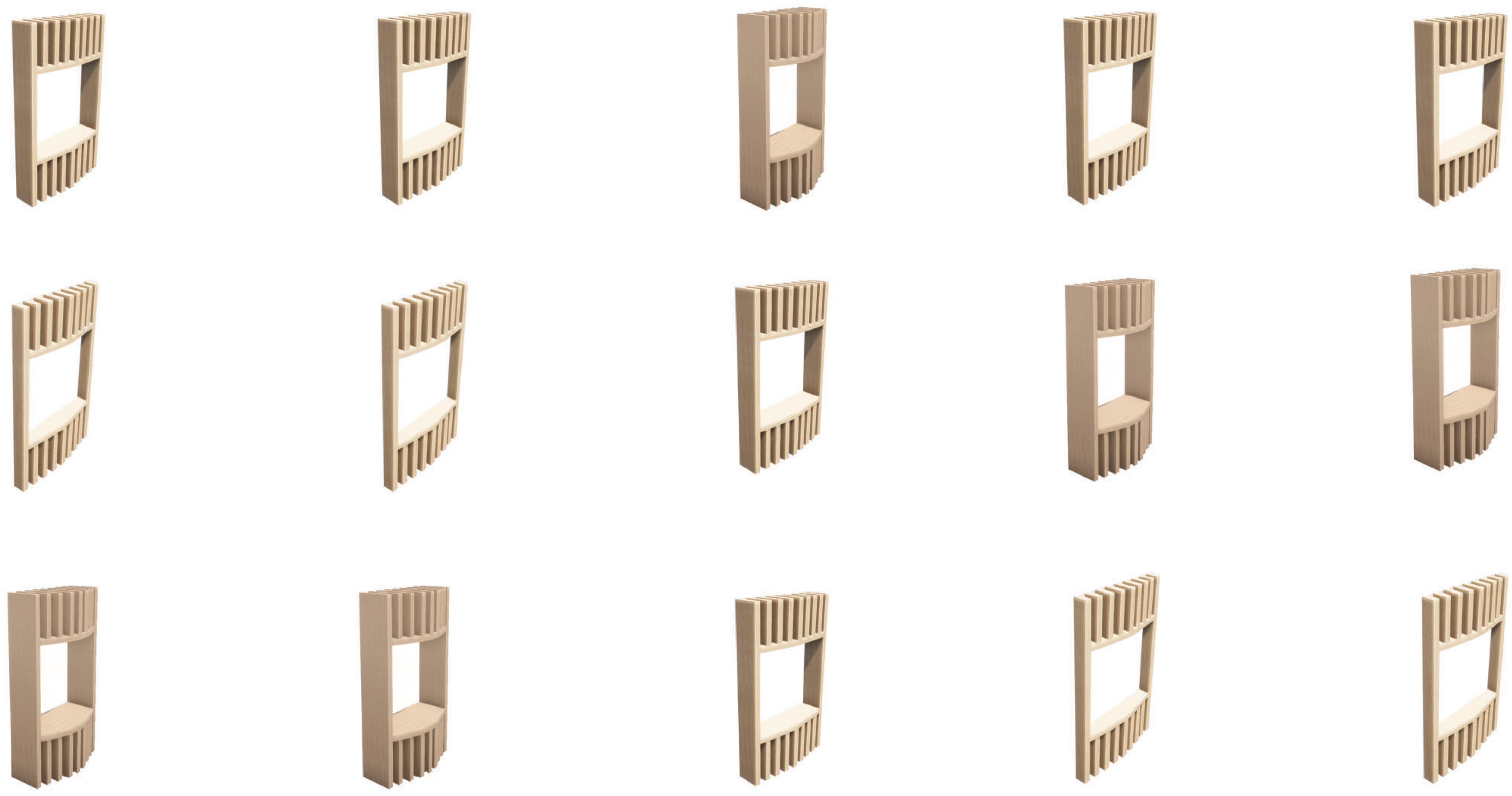
SOUTHERN HEMISPHERE REQUIRES DEEPER COVERINGS AS THE NORTHERN FACADE WILL ALWAYS RECIEVE THE MOST DIRECT SUN.

SOUTH

DUE TO VARYING ANGLES OF INCIDENCE, EACH LONGITUDE REQUIRES DIFFERENT SIZED WINDOW COVERINGS.

SOUTHERN HEMISPHERE REQUIRES SHALLOW COVERINGS AS IT WILL NEVER HAVE DIRECT SUN PENETRATION.

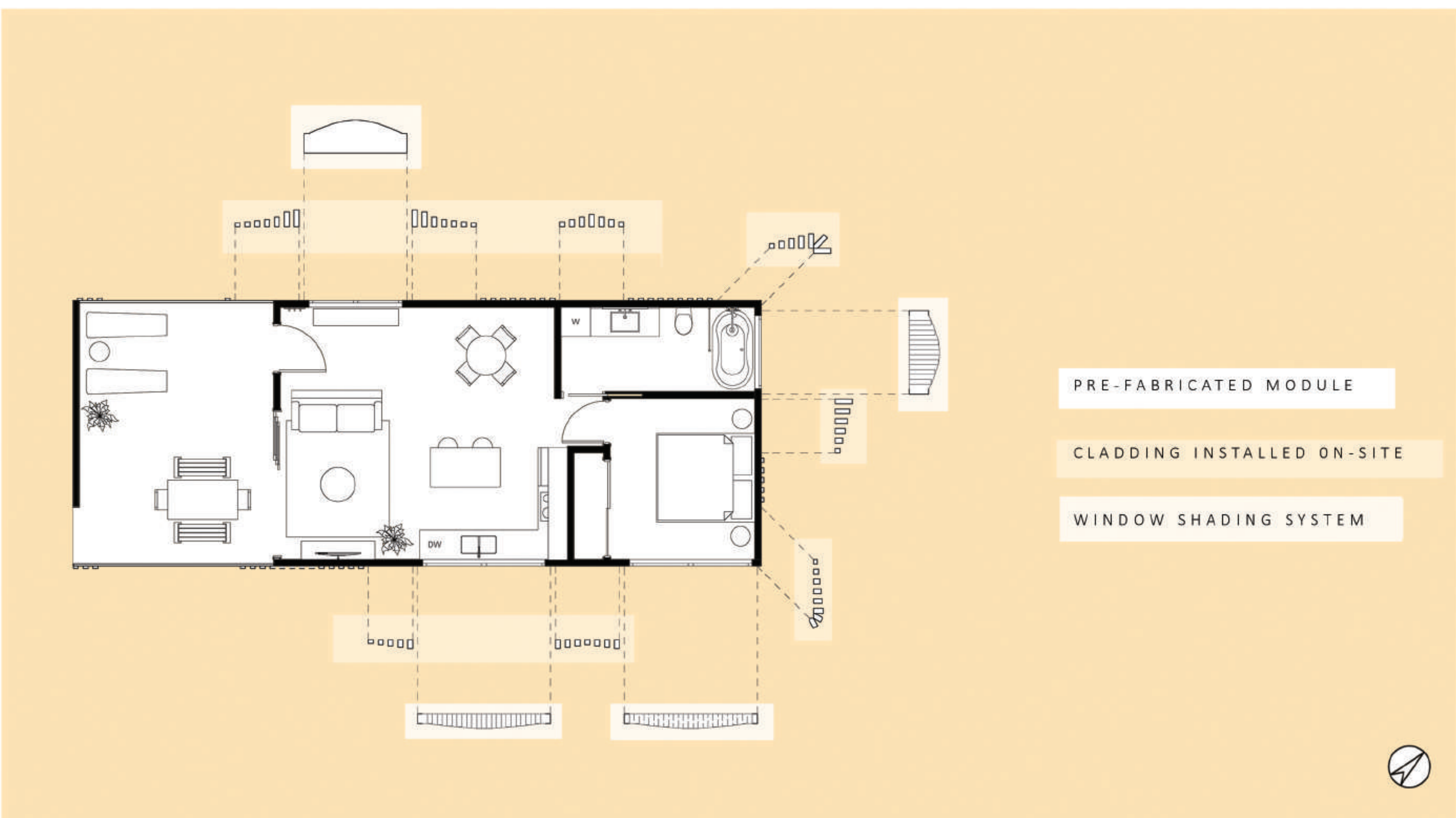
NORTHERN HEMISPHERE REQUIRES DEEPER COVERINGS AS THE NORTHERN FACADE WILL ALWAYS RECIEVE THE MOST DIRECT SUN.

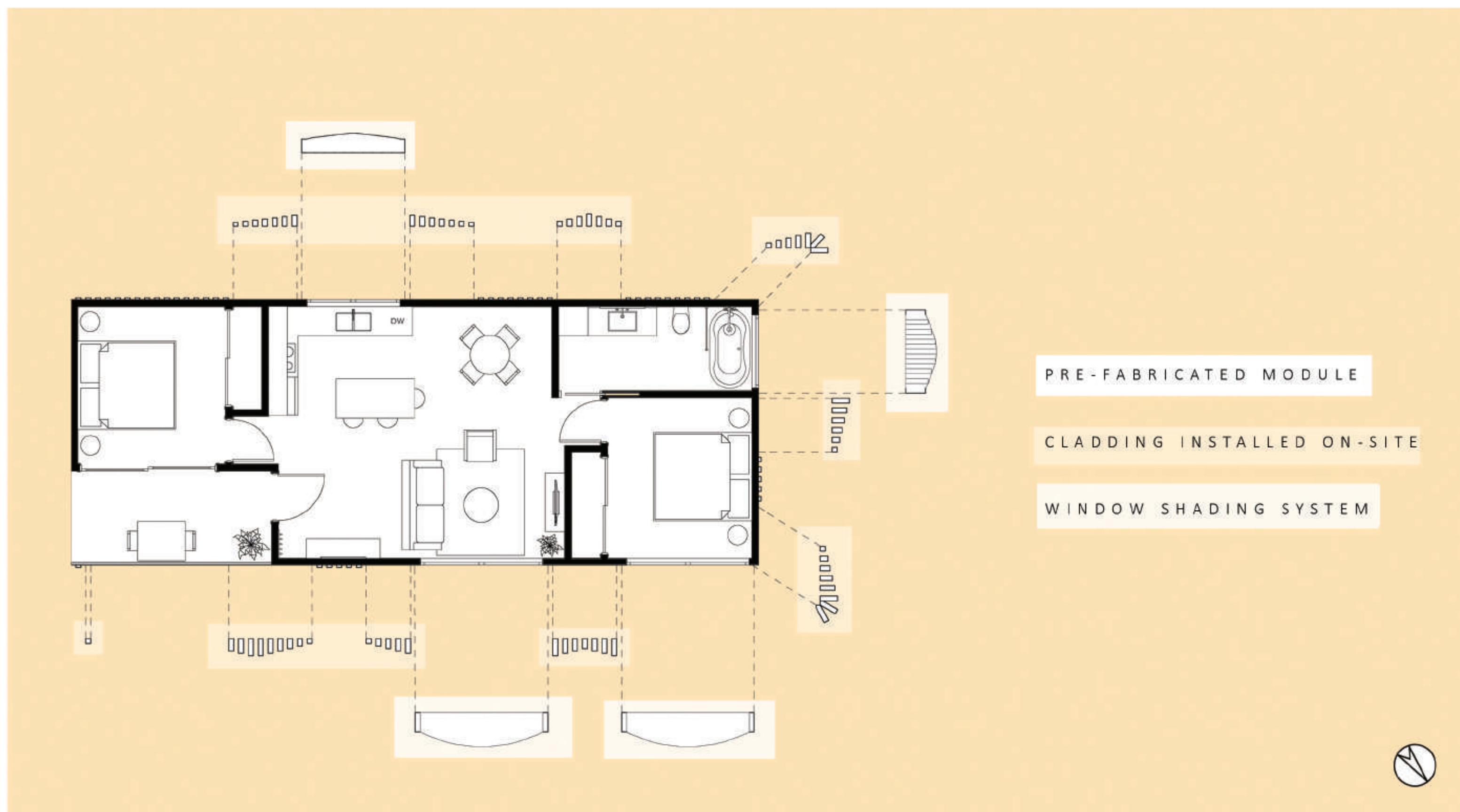


BY TESTING SUN SHADING WITH VARIOUS LENGTHS AND SHAPES, THIS SHADING SYSTEM WORKS EFFICIENTLY TO PREVENT HEAT GAIN DURING SUMMER AND ALLOW OPTIMUM SUN DURING WINTER. DEPENDING ON THE ORIENTATION OF THE MODULE, SOME BLOCKS WILL HAVE MORE SUN THAN OTHERS, BUT BY PRIORITISING CERTAIN INTERIOR SPACES FOR WINTER SUN, LIKE BEDROOMS AND LIVING SPACES, THE INTERIOR LIVING SPACES CAN BE PASSIVELY THERMALLY COMFORTABLE.

THE BALCONY SPACES ALSO HAVE AMPLE WINTER SUN SO THEY ARE STILL THERMALLY COMFORTABLE. IN AUSTRALIA OUR WINTERS ARE NOT TOO EXTREME, SO A SUNNY BALCONY IS STILL WARM ENOUGH IF SHELTERED FROM WIND AND RAIN, LIKE THESE MODULES.

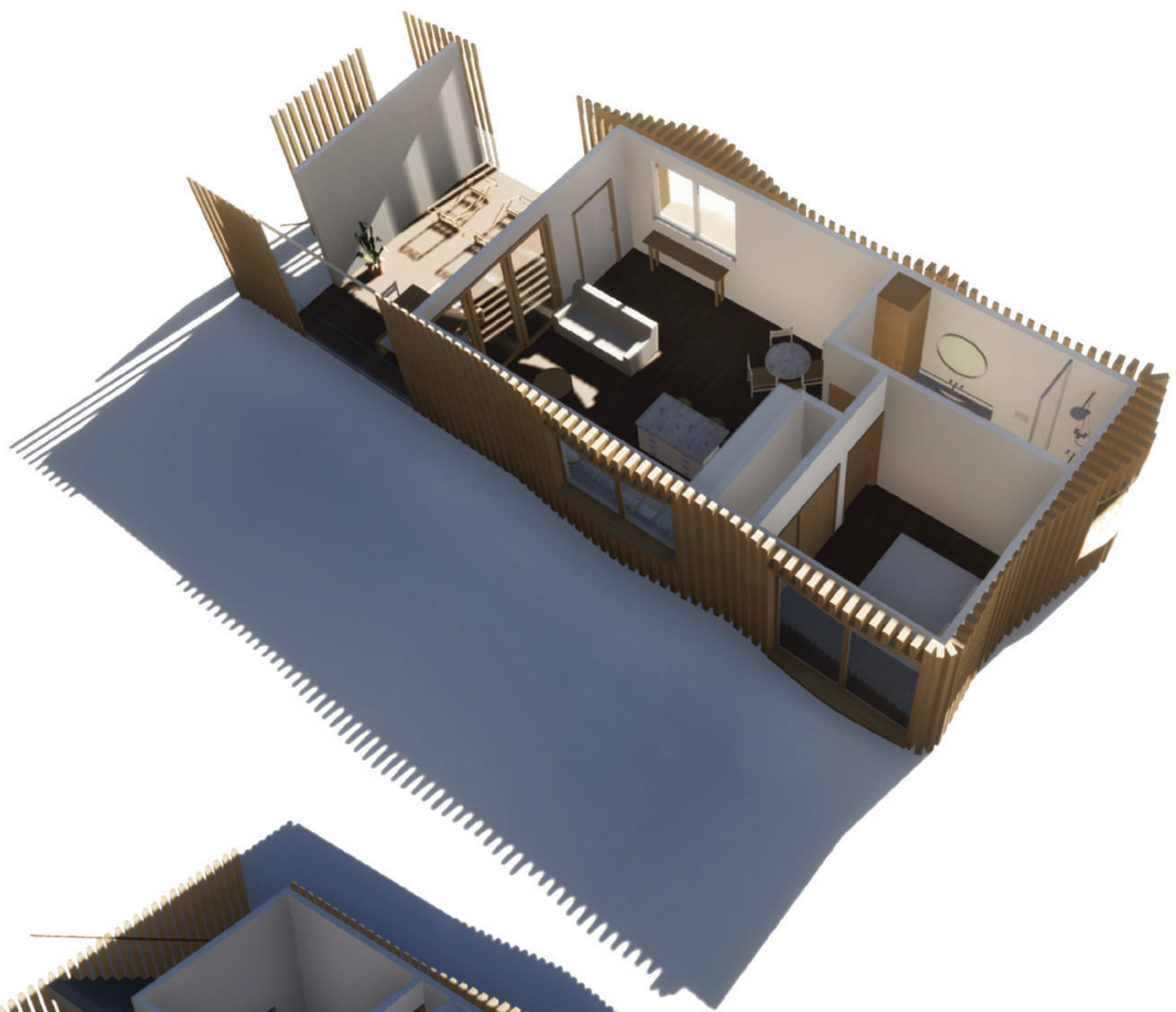
A MODULE DESIGN WAS TESTED IN VARIOUS LONGITUDINAL DEGREES (AS DISPLAYED ABOVE) AND THESE WINDOW COVERING DEPTHS WERE THE MOST SUITABLE. THEY ALLOWED WINTER SUN TO PENETRATE AT ALL TIMES OF THE DAY BUT NONE IN SUMMER DURING THE MIDDLE OF THE DAY. THIS MEANS THE MODULES WILL GET DIRECT SUNLIGHT, BUT NOT AT THE WARMEST TIMES OF THE DAY.



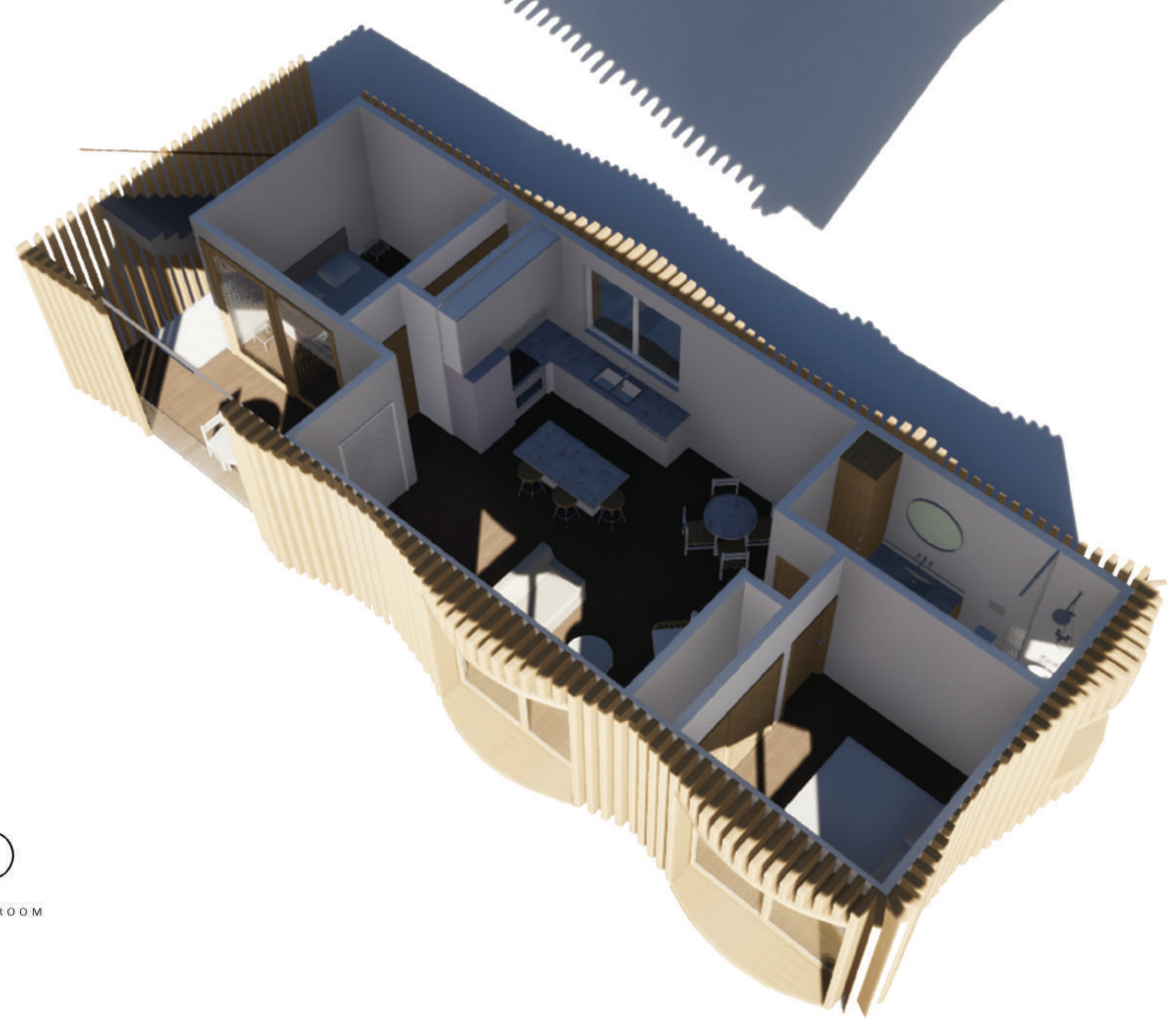


WINTER 12PM

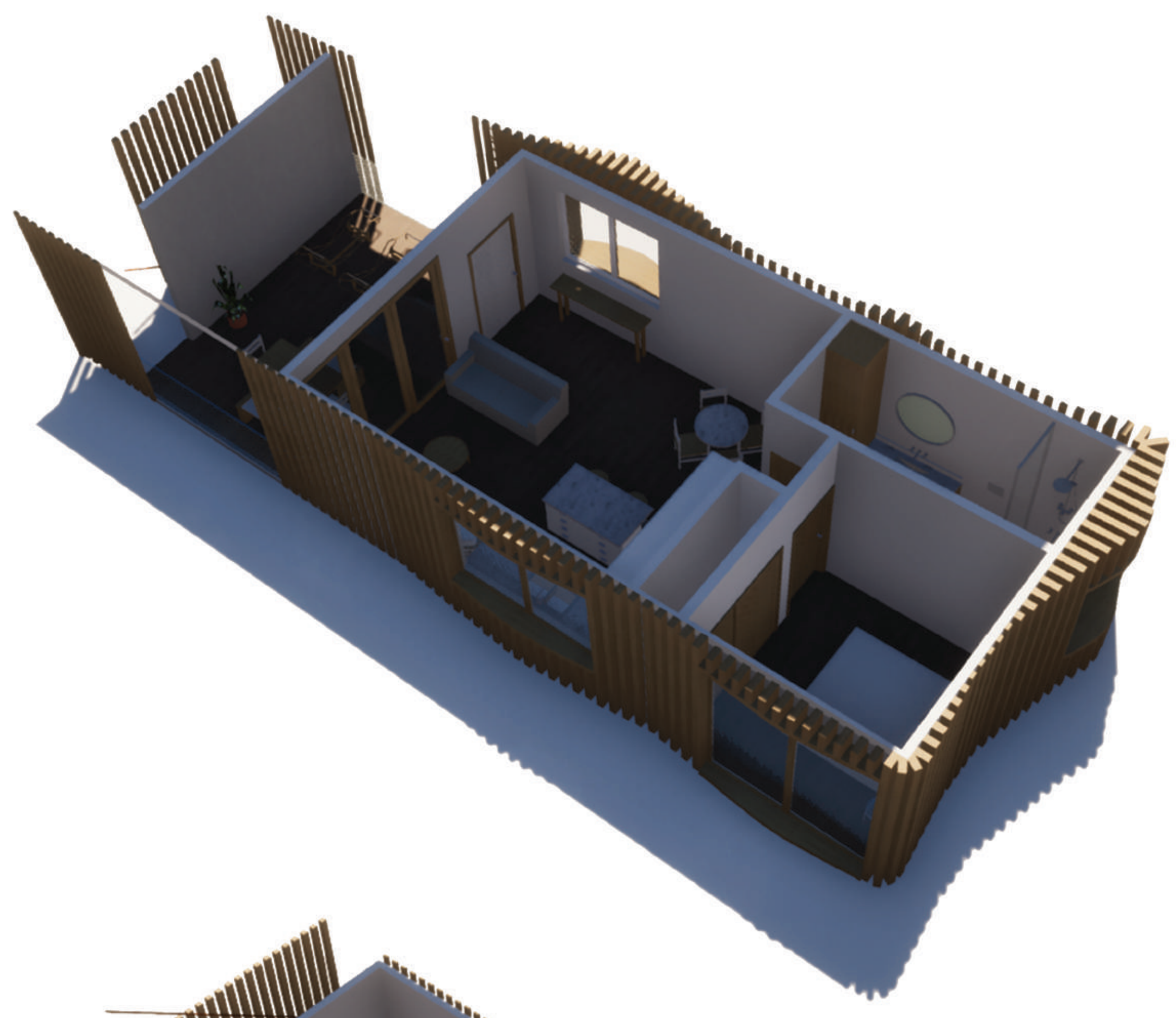
SUMMER 12PM

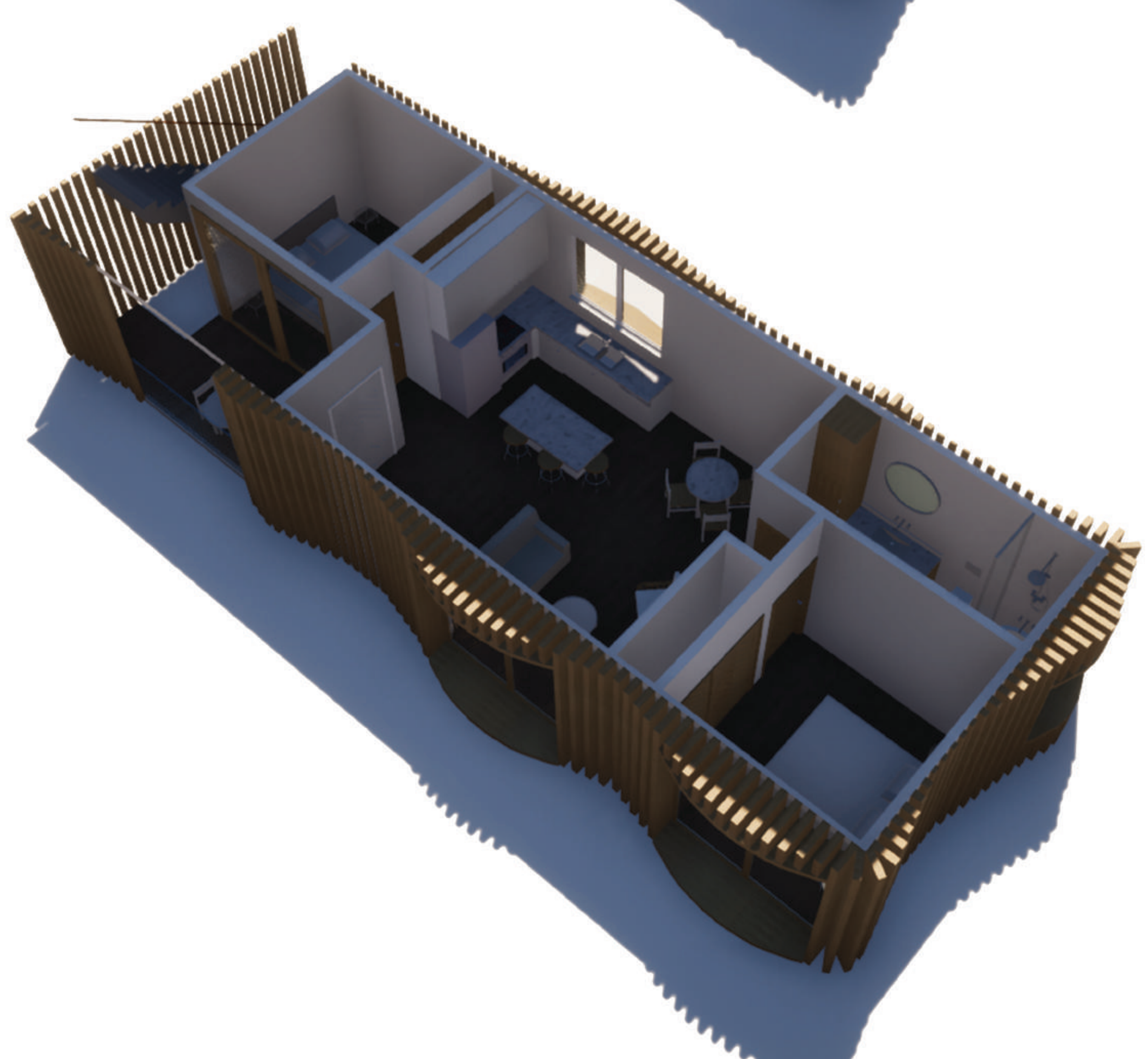


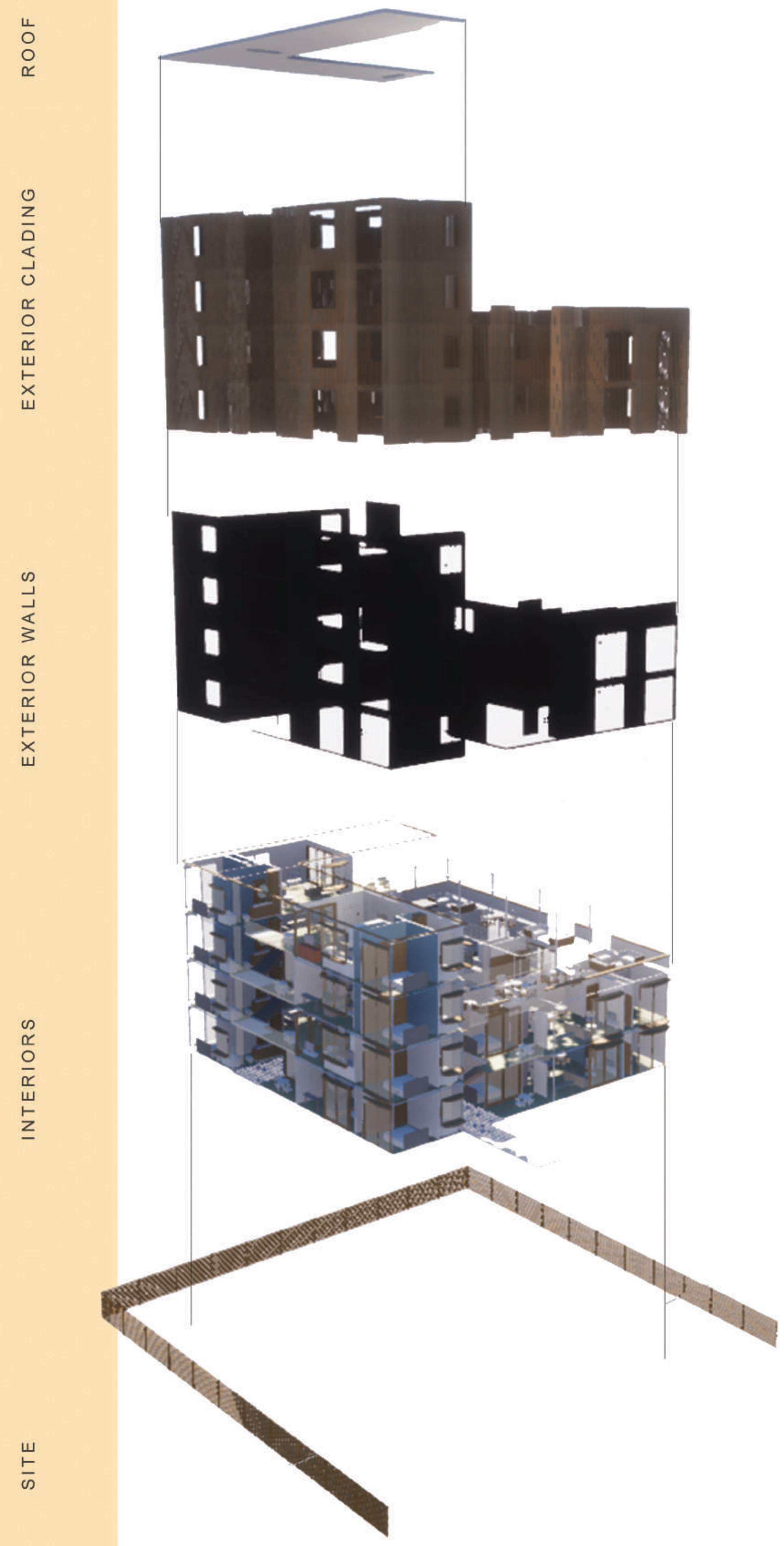
1 BEDROOM



2 BEDROOM



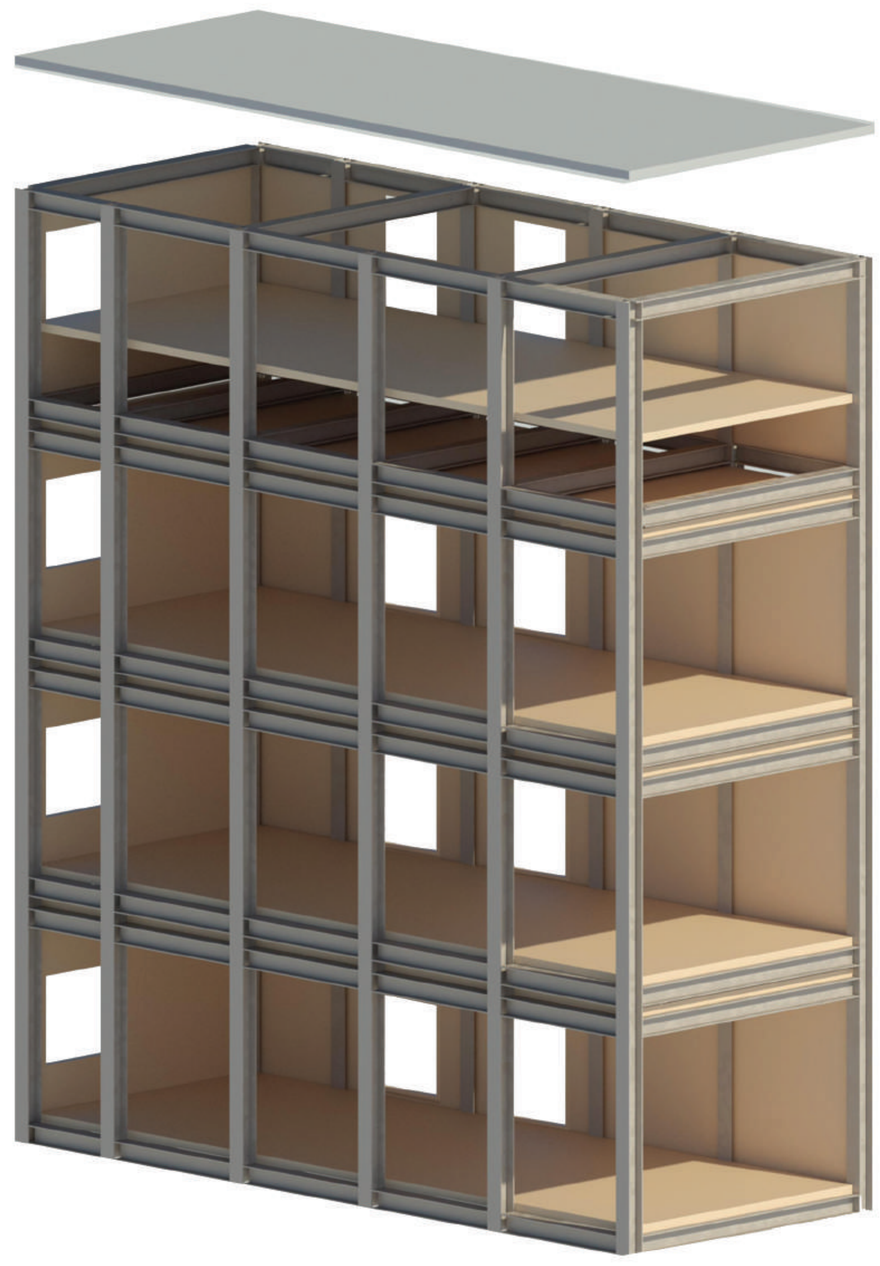




CONSTRUCTION DETAILS

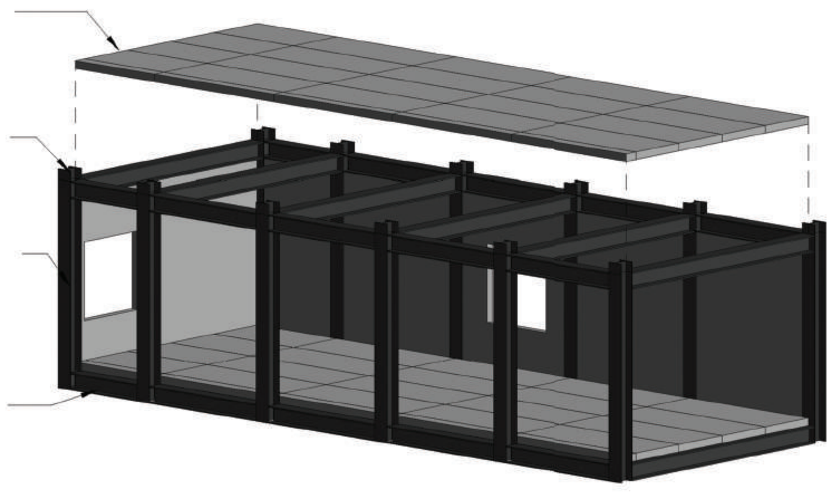
FOR THE CONSTRUCTION OF MY PREFABRICATED MODULES I WANTED A MATERIAL THAT WOULD LOWER CONSTRUCTION WASTE, LOWER CONSTRUCTION TIME AND THEREFORE TRADES COST, REDUCE THERMAL BRIDGING AND HAVE A HIGH R-VALUE FOR SUSTAINABLE PASSIVE DESIGN. SIPS PANELS WERE CHOSEN AS THEY HAVE AS THESE QUALITIES, AND IF HANDLED WITH EXPERIENCED HANDS, CAN BE ECONOMICALLY CHEAPER THAN STANDARDISED BUILDING METHODS. SIPS PANELS, ALONG WITH STEEL FRAMING, CAN BE USED FOR THE CONSTRUCTION OF WALLS, FLOORS AND ROOFS, LIMITING VARYING TRADES. THE USE OF SIPS AND THEIR FOOTING SYSTEM REDUCES EXCAVATION, SITE DISTURBANCE AND THE NEED FOR CONCRETE. FOR TWO STOREY DESIGNS, A STEEL 4 POINT FRAMING SYSTEM USED IN CONJUNCTION WITH SIPFORM QUIET FLOOR PANELS TO REDUCE NOISE POLLUTION OR REGULAR SIPFORM PANELS WHICH CAN SPAN LONGER DISTANCES. I DESIGNED USING A PARAPET ROOF SYSTEM TO ADD TO THE MINIMAL DESIGN AND TO ALSO REDUCE COSTS FOR TIMBER ROOF FRAMING. INSULATED PANEL ROOFING CAN BE CONSTRUCTED USING THE SAME METHOD AS THE UPPER FLOORS AS THEY ARE SELF-SUPPORTING. THESE INSULATED PANELS ARE THEN LINED WITH A WATERPROOF MEMBRANE AND FITTED WITH TIMBER BATTENS AND A SLOPED ROOFING SYSTEM TO AID WITH WATER DRAINAGE. SIPS WERE CHOSEN AS THEY ARE ESSENTIALLY AN ALL IN ONE PREFABRICATED PRODUCT, THAT WHEN DESIGNED TO THEIR SPECIFICATIONS, CAN BE QUICK TO ERECT AND CHEAP. THEIR INSULATING AND STRUCTURAL QUALITIES MEAN THEY ARE THERMALLY COMFORTABLE, REDUCE ENERGY COSTS, AND REDUCE NOISE POLLUTION FOR MORE PRIVACY IN AN APARTMENT STYLE BUILDING.

STRUCTURAL BEAM SYSTEM

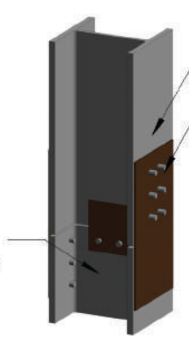


UPON MORE RESEARCH, MY ENGINEERS FOUND THAT THIS DESIGN WAS OVERKILL IN REGARD TO SUPPORTING THE FLOOR SYSTEM WITH 3 LAYERS OF BEAMS. INSTEAD, MY DESIGN WILL COMPRISE OF ONE LAYER ON THE FIRST, SECOND AND THIRD FLOOR (SIMILAIR TO THE GROUND FLOOR AND ROOF) AND INCORPORATE BOTH FUNCTIONS OF A CEILING AND FLOOR FOR THE MODULES. THIS MEANS SOME MODULES WILL BE PREFABRICATED WITHOUT THE ROOF SYSTEM ATTACHED, BUT THIS WILL SAVE MATERIALS, CONSTRUCTION COSTS AND WEIGHT.

MODULE CONSTRUCTION



DETAIL OF KEY MODULE CONNECTION

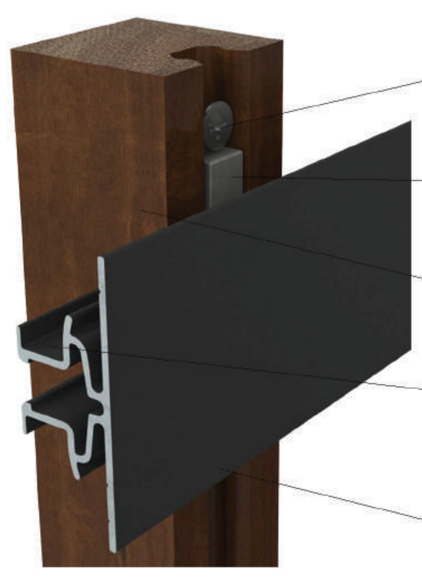


FACADE DETAILS

AS THIS PROJECT NEEDS THE CAPABILITIES TO BE DISASSEMBLED AND RELOCATED, I WANTED THE FAÇADE AND SHADING DEVICES TO BE A CLIP-ON LIKE SYSTEM SO THAT THE DESIGN CAN BE ANY ORIENTATION AND STILL BE SUFFICIENTLY SHADED. I CAME UP WITH THE IDEA OF A SIMPLE RECTANGULAR MODULE BUT WITH A CURVED EXTERIOR, SO THE INTERIOR DESIGN WAS PRACTICAL, CONSTRUCTION WAS SIMPLE, BUT THE FAÇADE WAS DYNAMIC. WHILST LOOKING AT BASIC CLADDING OPTIONS I THOUGHT OF A WAY TO CUSTOMISE A PRE-EXISTING PRODUCT TO MAKE A UNIQUE SUN SHADING AND FAÇADE SYSTEM FOR THE SIPS MODULES THAT WAS COST EFFECTIVE. BY USING SCULPTFORM CLICK ON BATTENS AND ALTERNATING THEIR DEPTHS, I CREATED A SYSTEM THAT PROTRUDED AROUND WINDOWS TO ACT AS A SHADING DEVICE AND HUGGED THE REGULAR WALL STRUCTURE, CREATING A FLOWING EFFECT AROUND THE BUILDINGS OPENINGS. BY MODELLING THE DESIGN IN SKETCHUP, I WAS ABLE TO SEE WHICH DEPTHS WOULD SUFFICIENTLY SHADE DURING THE SUMMER MONTHS AND ALLOW LIGHT DURING WINTER (WHICH ARE MODELLED ON THE FAÇADE SYSTEM PANEL). THIS SYSTEM USES A SIMPLE MOUNTING TRACK WHICH CAN BE ATTACHED TO THE TIMBER BATTENS THAT CONNECT THE SIPS WALL PANELS, SO ONCE THE SIPS WALL PANELS ARE INSTALLED, A WATERPROOF LAYER IS ADDED FOLLOWED BY THE MOUNTING TRACK. AT THIS STAGE IN THE PROJECT I HAVE OPTED FOR TIMBER BATTENS OPPOSED TO POWDER COATED STEEL OR TIMBER CLADDED STEEL DUE TO THEIR THERMAL BRIDGING QUALITIES, BUT I HAVE DESIGNED A DOWNPIPE SYSTEM THAT IS A REGULAR SQUARE DOWNPIPE CLADDED WITH TIMBER SO IT BLENDS IN WITH TIMBER BATTENS. THIS MAY CHANGE AS TIMBER IS HEAVER AND REQUIRES MORE STRUCTURAL SUPPORT, BUT I WILL EXPLORE THIS FURTHER FOR THE NEXT ASSIGNMENT.

IMAGES INSPIRED BY SCULPTFORM BATTEN SYSTEM,
Sculptform. 2020. "Timber Click on Battens."
https://sculptform.com.au/products/click-on-battens/

FACADE MOUNTING SYSTEM (BACK VIEW)

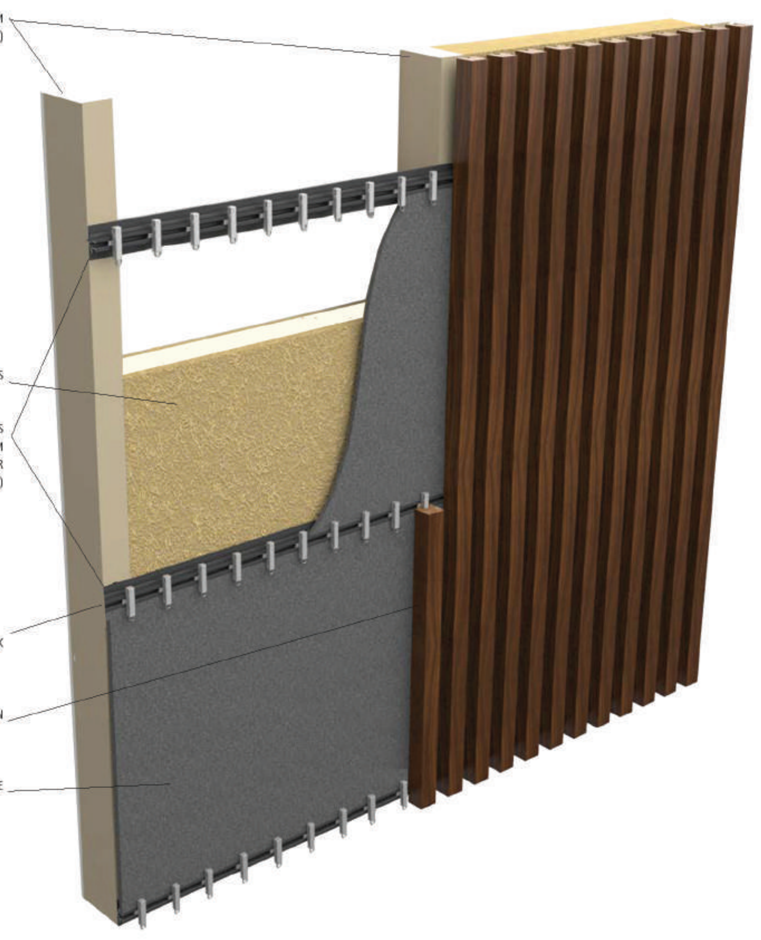


EXTERNAL CORNER DETAIL

BATTEN JOINER DIAGRAM

BATTEN JOINERS ARE REQUIRED TO SECURE EACH BATTEN TOGETHER. AS THIS DESIGN SPANS 4 FLOORS, THERE NEEDS TO BE AT LEAST 4 BATTEN JOINERS FROM GROUND FLOOR TO THE ROOF.

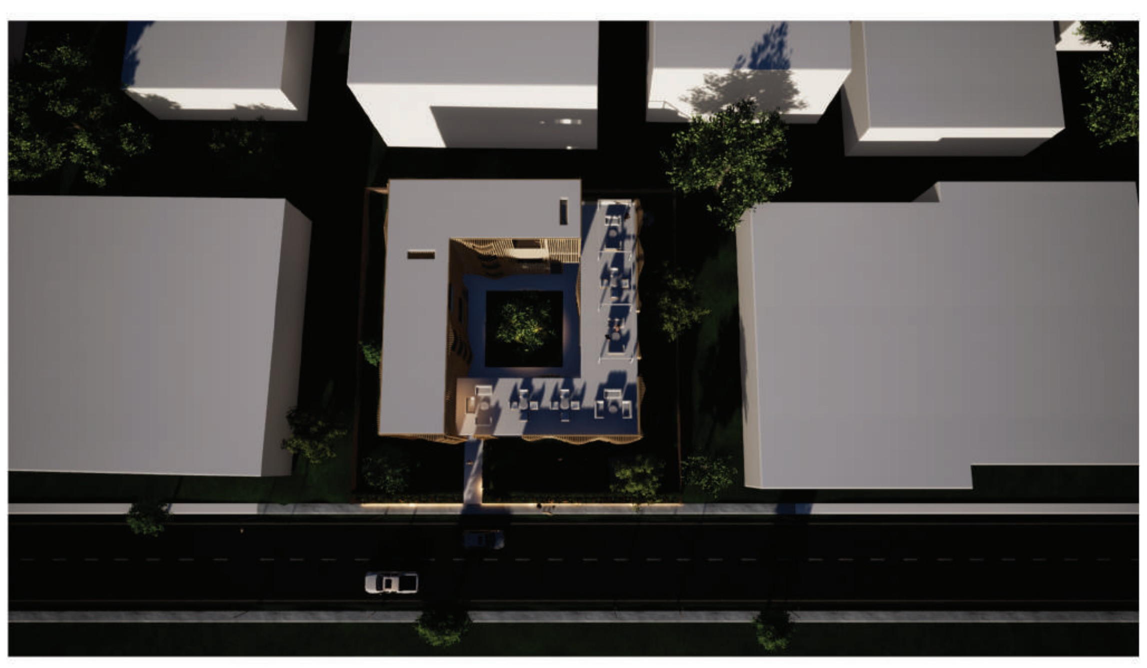
TIMBER FACADE SYSTEM



OVERSHADOWING



JANUARY 9AM | 12PM | 6PM



JULY 9AM | 12PM | 6PM

SECTIONAL PERSPECTIVE

RENDERS

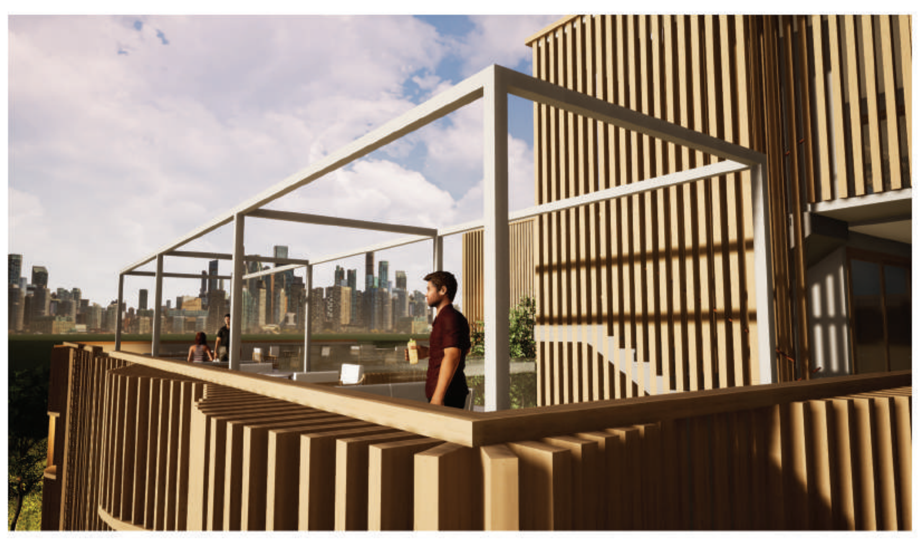
EXTERIOR

APPROACH

SHARED SPACES

PRIVATE SPACES

PUBLIC SPACES



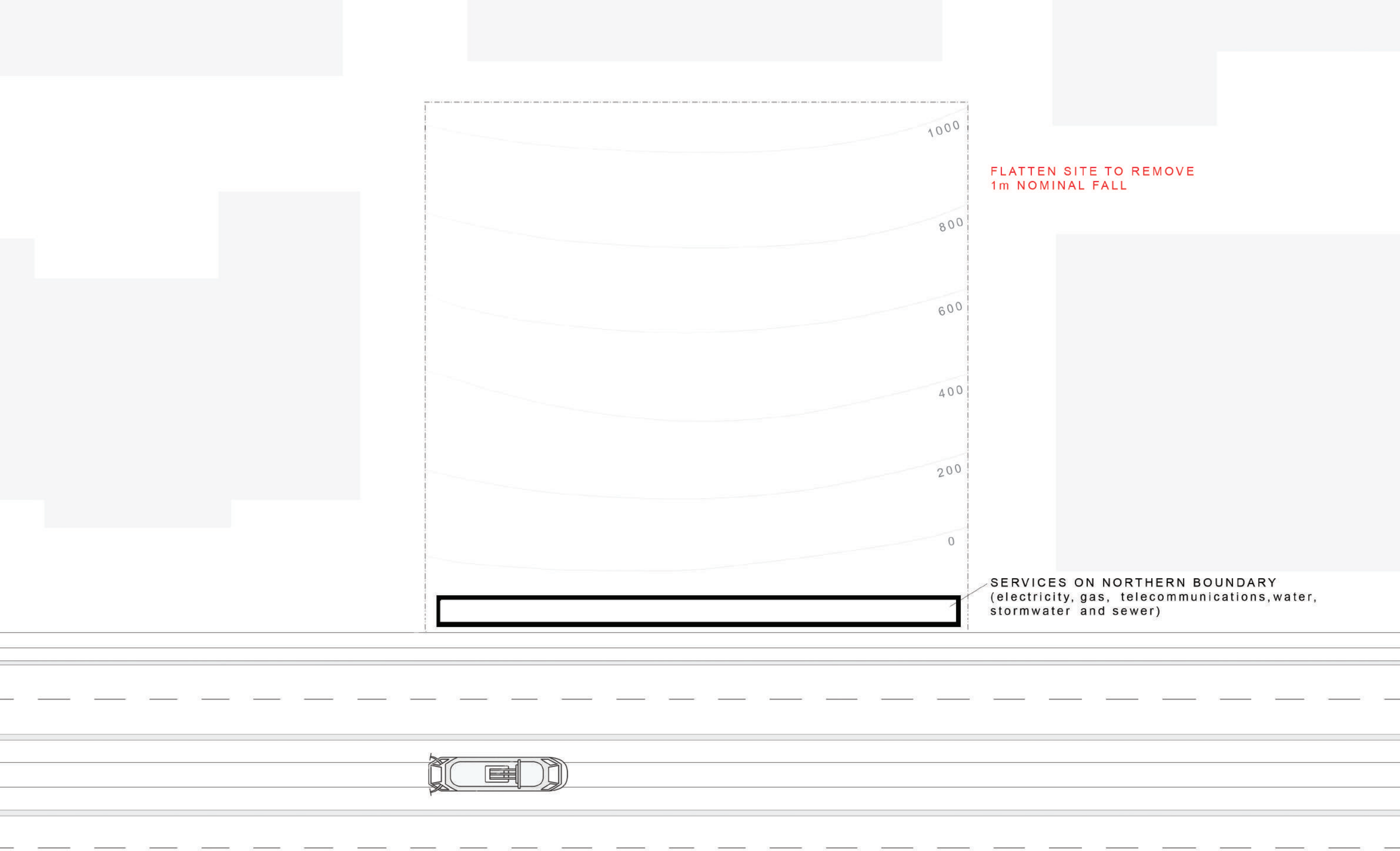
BUILDING DRAWINGS

[redacted]

Unit: Integrated Buildings Research Methods and Studio 2020
Project name: FLEETWOOD MODULAR PROJECT
Site: Melbourne
Description: Affordable and movable modular housing complex consisting of 10x 2 bedroom modules and 4x 1 bedroom modules.

PROPOSED SITE PLAN
1:200 @ A3

18/06/2020



[redacted]

Unit: Integrated Buildings Research Methods and Studio 2020
Project name: FLEETWOOD MODULAR PROJECT
Site: Melbourne
Description: Affordable and movable modular housing complex consisting of 10x 2 bedroom modules and 4x 1 bedroom modules.

DEMOLITION PLAN/EXISTING SITE
1:200 @ A3

18/06/2020

[redacted]

Unit: Integrated Buildings Research Methods and Studio 2020
Project name: FLEETWOOD MODULAR PROJECT
Site: Melbourne
Description: Affordable and movable modular housing complex consisting of 10x 2 bedroom modules and 4x 1 bedroom modules.

FLOOR PLAN
LEVEL 0
1:100 @ A3

18/06/2020

[redacted]

Unit: Integrated Buildings Research Methods and Studio 2020
Project name: FLEETWOOD MODULAR PROJECT
Site: Melbourne
Description: Affordable and movable modular housing complex consisting of 10x 2 bedroom modules and 4x 1 bedroom modules.

FLOOR PLAN
LEVEL 1
1:100 @ A3

18/06/2020

[redacted]

Unit: Integrated Buildings Research Methods and Studio 2020
Project name: FLEETWOOD MODULAR PROJECT
Site: Melbourne
Description: Affordable and movable modular housing complex consisting of 10x 2 bedroom modules and 4x 1 bedroom modules.

FLOOR PLAN
LEVEL 2
1:100 @ A3

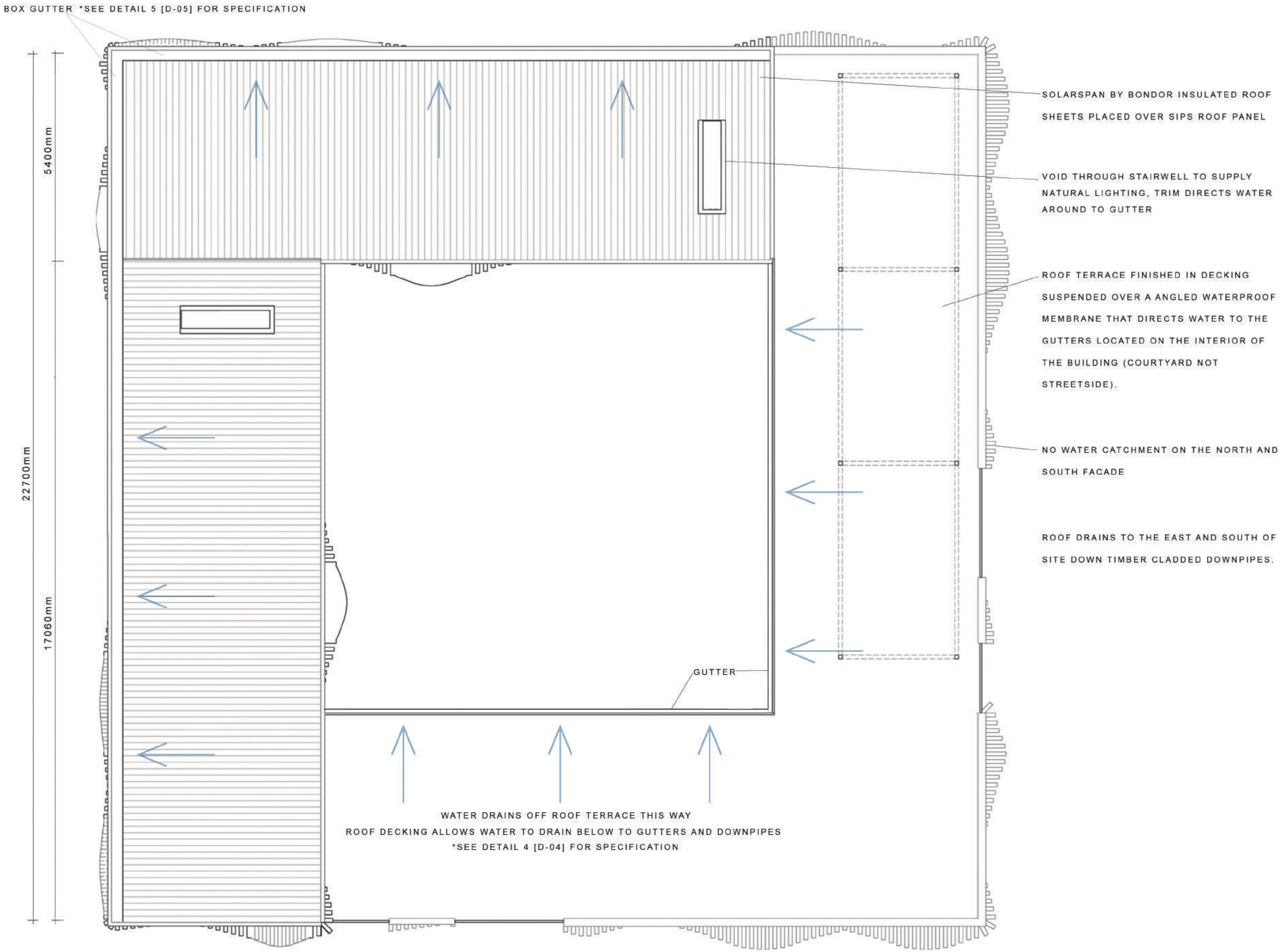
18/06/2020

[redacted]

Unit: Integrated Buildings Research Methods and Studio 2020
Project name: FLEETWOOD MODULAR PROJECT
Site: Melbourne
Description: Affordable and movable modular housing complex consisting of 10x 2 bedroom modules and 4x 1 bedroom modules.

FLOOR PLAN
LEVEL 3
1:100 @ A3

18/06/2020

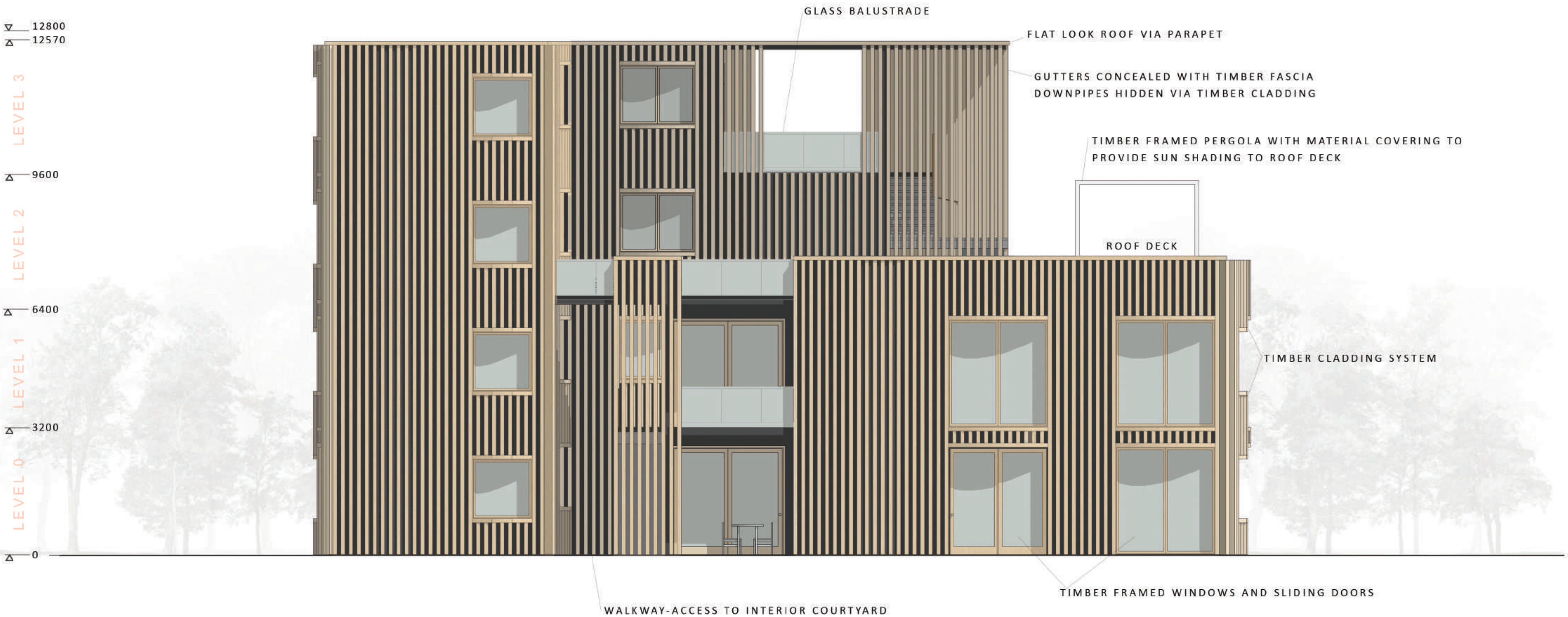


[redacted]

Unit: Integrated Buildings Research Methods and Studio 2020
Project name: FLEETWOOD MODULAR PROJECT
Site: Melbourne
Description: Affordable and movable modular housing complex consisting of 10x 2 bedroom modules and 4x 1 bedroom modules.

ROOF PLAN
1:100 @ A3

18/06/2020



[redacted]

Unit: Integrated Buildings Research Methods and Studio 2020
Project name: FLEETWOOD MODULAR PROJECT
Site: Melbourne
Description: Affordable and movable modular housing complex consisting of 10x 2 bedroom modules and 4x 1 bedroom modules.

NORTH ELEVATION
1:100 @ A3

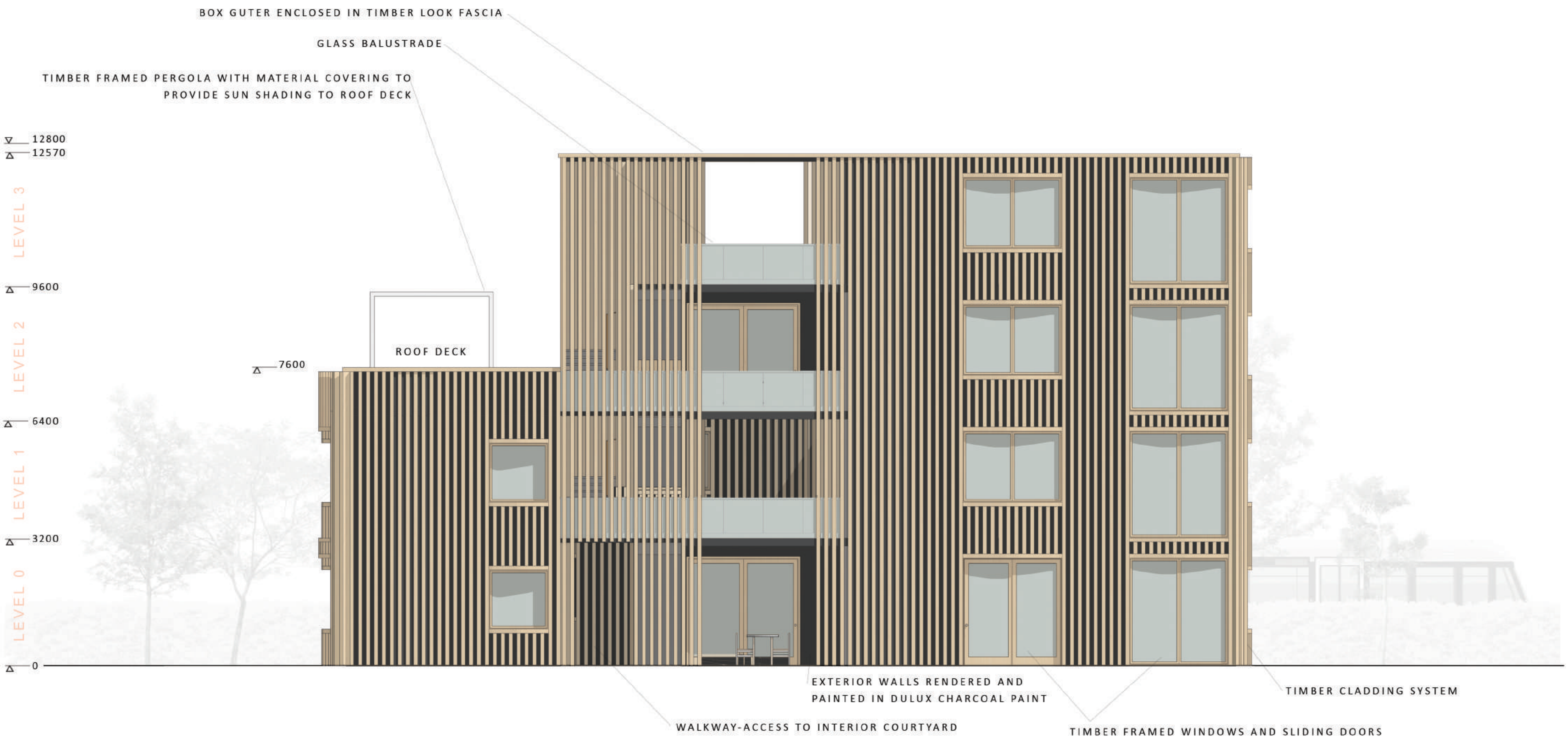
18/06/2020

[redacted]

Unit: Integrated Buildings Research Methods and Studio 2020
Project name: FLEETWOOD MODULAR PROJECT
Site: Melbourne
Description: Affordable and movable modular housing complex consisting of 10x 2 bedroom modules and 4x 1 bedroom modules.

EAST ELEVATION
1:100 @ A3

18/06/2020

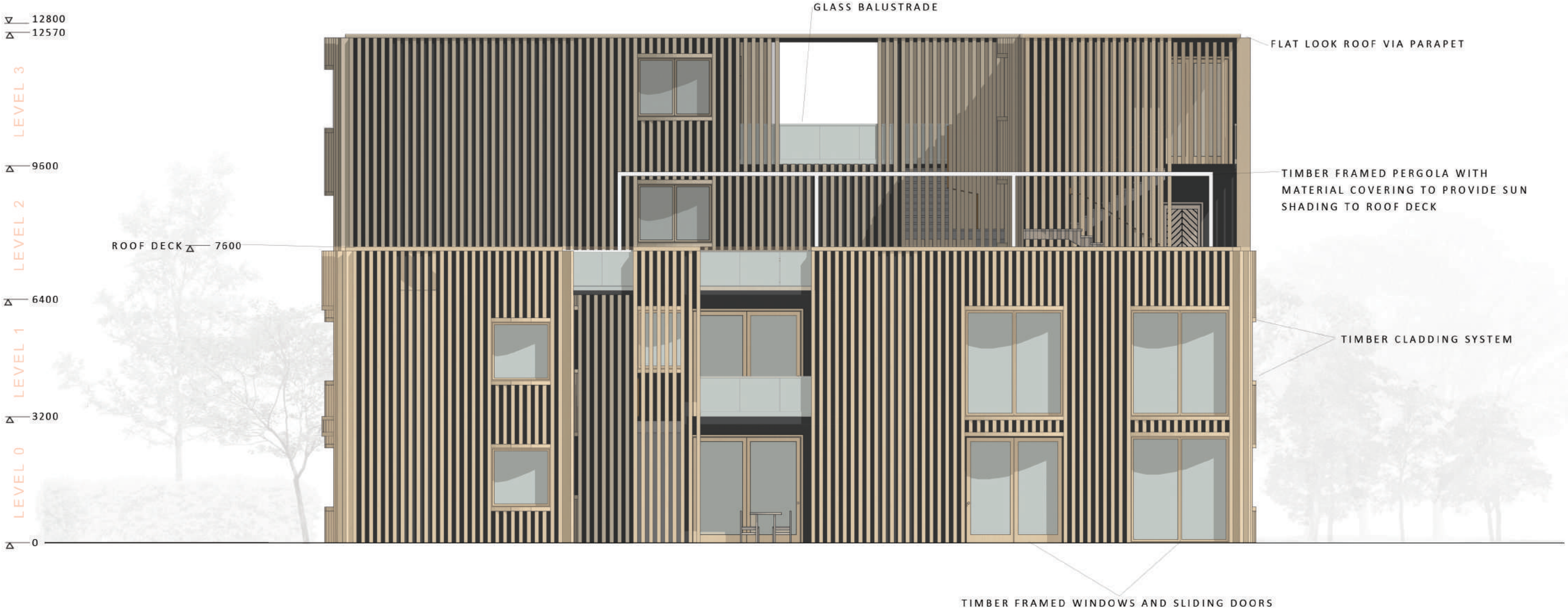


[redacted]

Unit: Integrated Buildings Research Methods and Studio 2020
Project name: FLEETWOOD MODULAR PROJECT
Site: Melbourne
Description: Affordable and movable modular housing complex consisting of 10x 2 bedroom modules and 4x 1 bedroom modules.

SOUTH ELEVATION
1:100 @ A3

18/06/2020

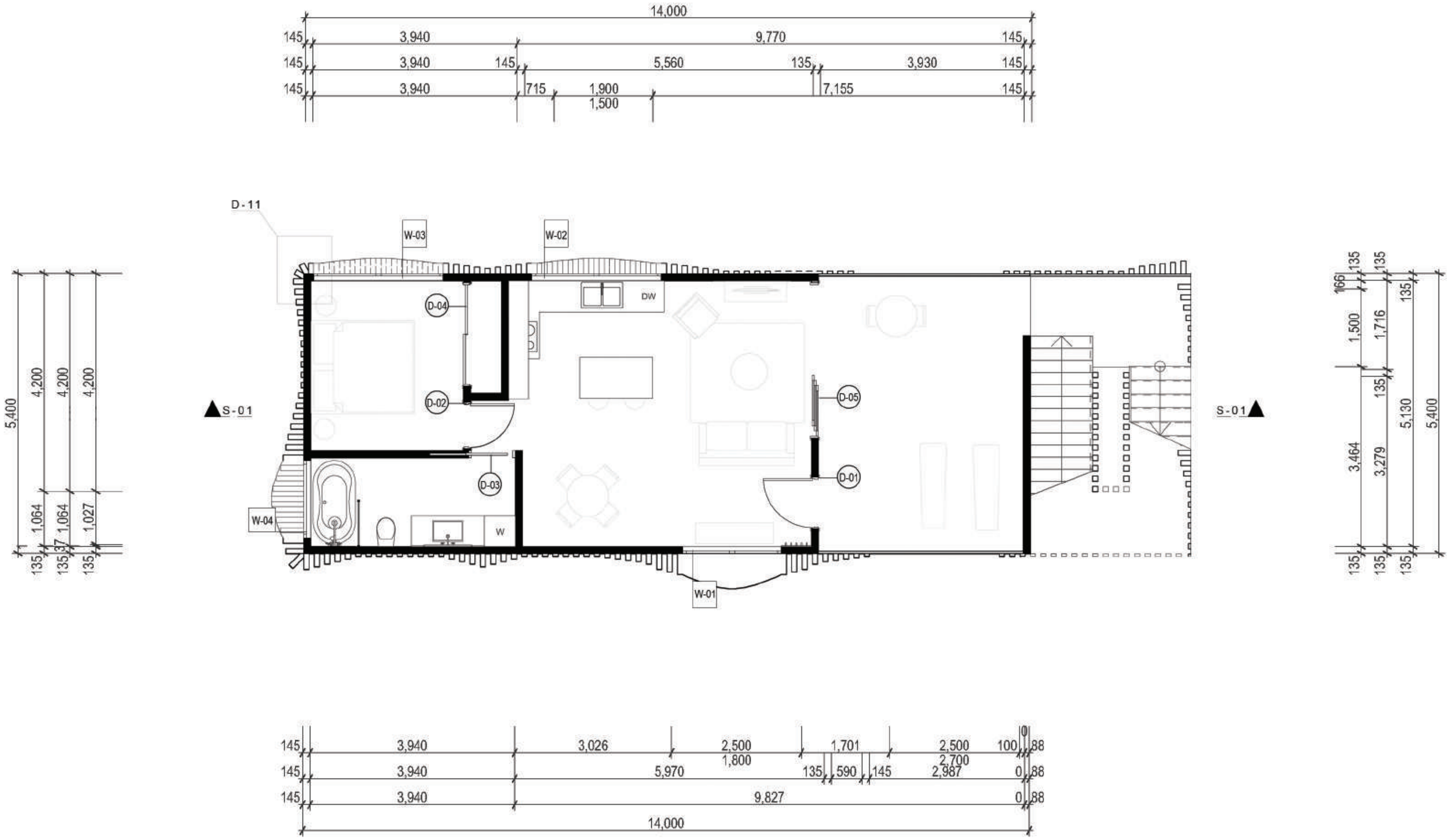


[redacted]

Unit: Integrated Buildings Research Methods and Studio 2020
Project name: FLEETWOOD MODULAR PROJECT
Site: Melbourne
Description: Affordable and movable modular housing complex consisting of 10x 2 bedroom modules and 4x 1 bedroom modules.

WEST ELEVATION
1:100 @ A3

18/06/2020



[redacted]

Unit: Integrated Buildings Research Methods and Studio 2020

Project name: FLEETWOOD MODULAR PROJECT

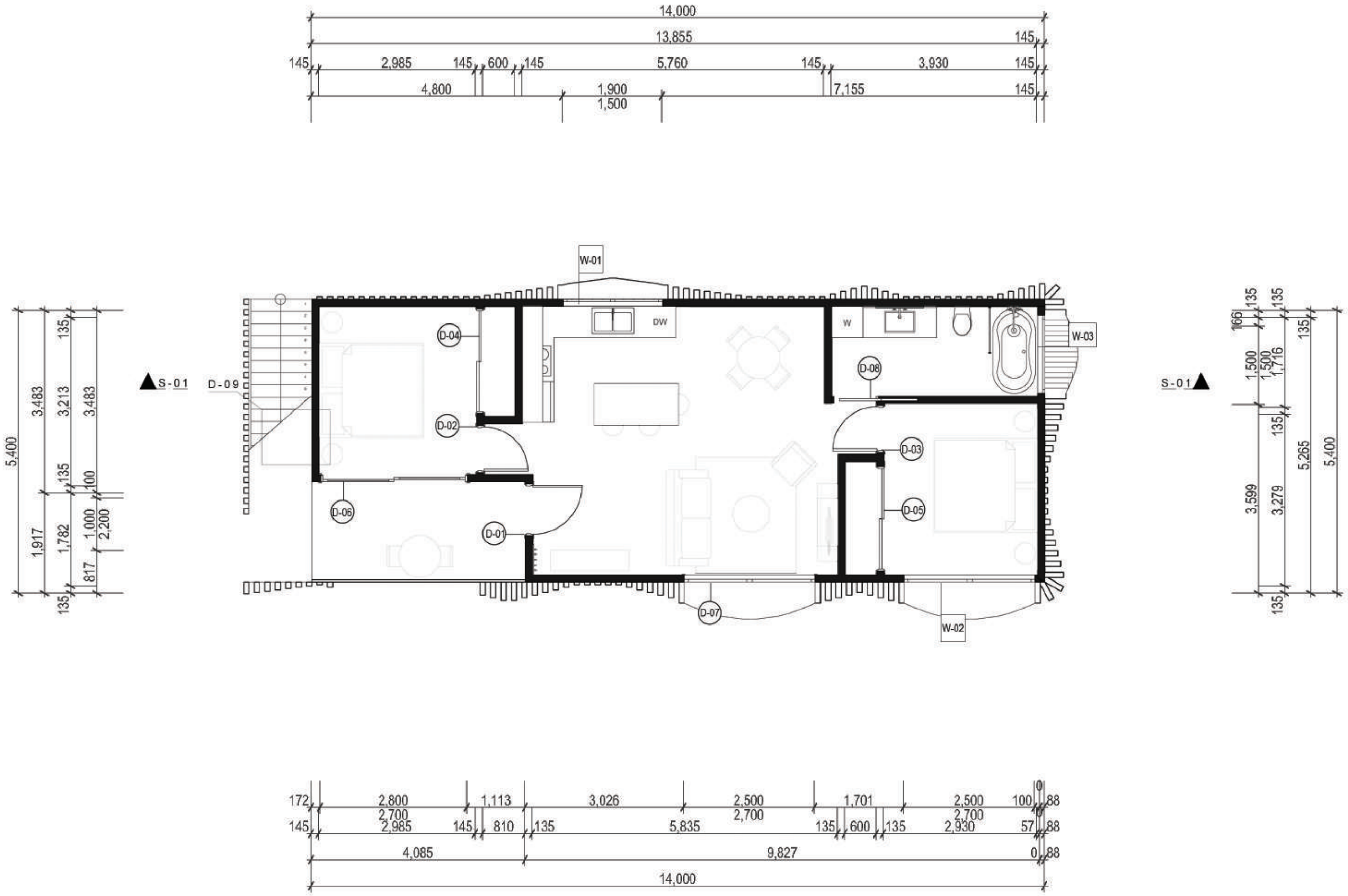
Site: Melbourne

Description: Affordable and movable modular housing complex consisting of 10x 2 bedroom modules and 4x 1 bedroom modules.

1 BEDROOM FLOOR PLAN

1:100 @ A3

18/06/2020



[redacted]

Unit: Integrated Buildings Research Methods and Studio 2020
Project name: FLEETWOOD MODULAR PROJECT
Site: Melbourne
Description: Affordable and movable modular housing complex consisting of 10x 2 bedroom modules and 4x 1 bedroom modules.

2 BEDROOM FLOOR PLAN

1:100 @ A3

18/06/2020

UPPER CABINETRY IN WHITE GLOSS TO REFLECT LIGHT AND CREATE THE ILLUSION OF A LARGER SPACE

WHITE HERRINGBONE TILE HAS BEEN DISPLAYED HERE BUT THIS CAN BE CUSTOMISABLE FOR THE CLIENTS STYLE

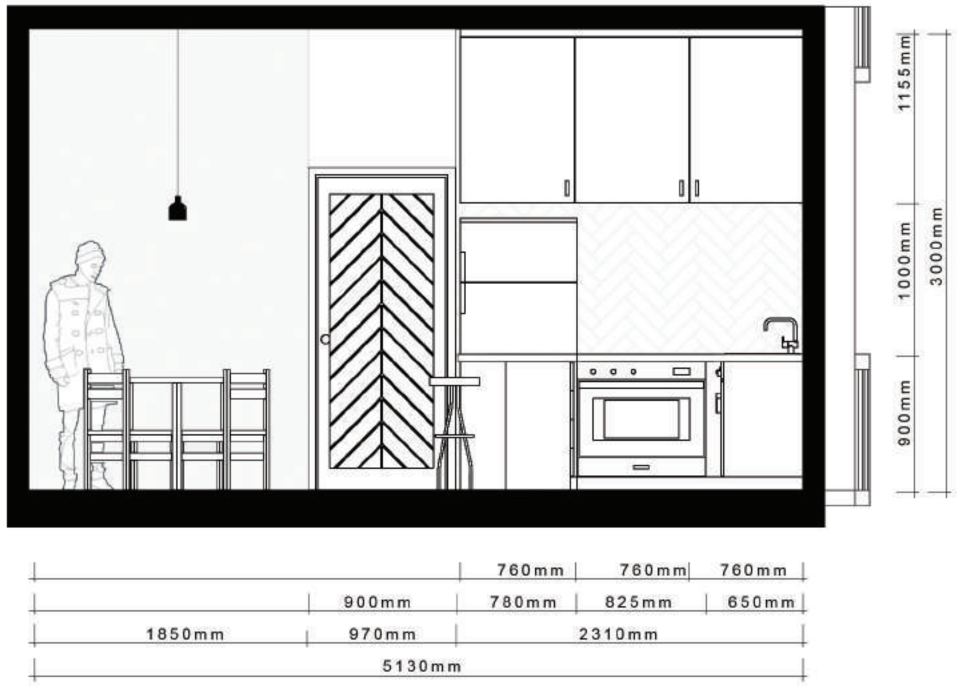
STONE COUNTERTOPS CUSTOMISABLE

BASE CABINET FRONTS CHOSEN TO MATCH UPPER CABINETS, CAN BE CUSTOMISABLE.

HERINGBONE TIMBER DOORS

DINING AREA WITH PENDANT LIGHT ABOVE (CUSTOMISABLE PENDANT FITTING CHOSEN BY CLIENT)

2 BEDROOM MODULE

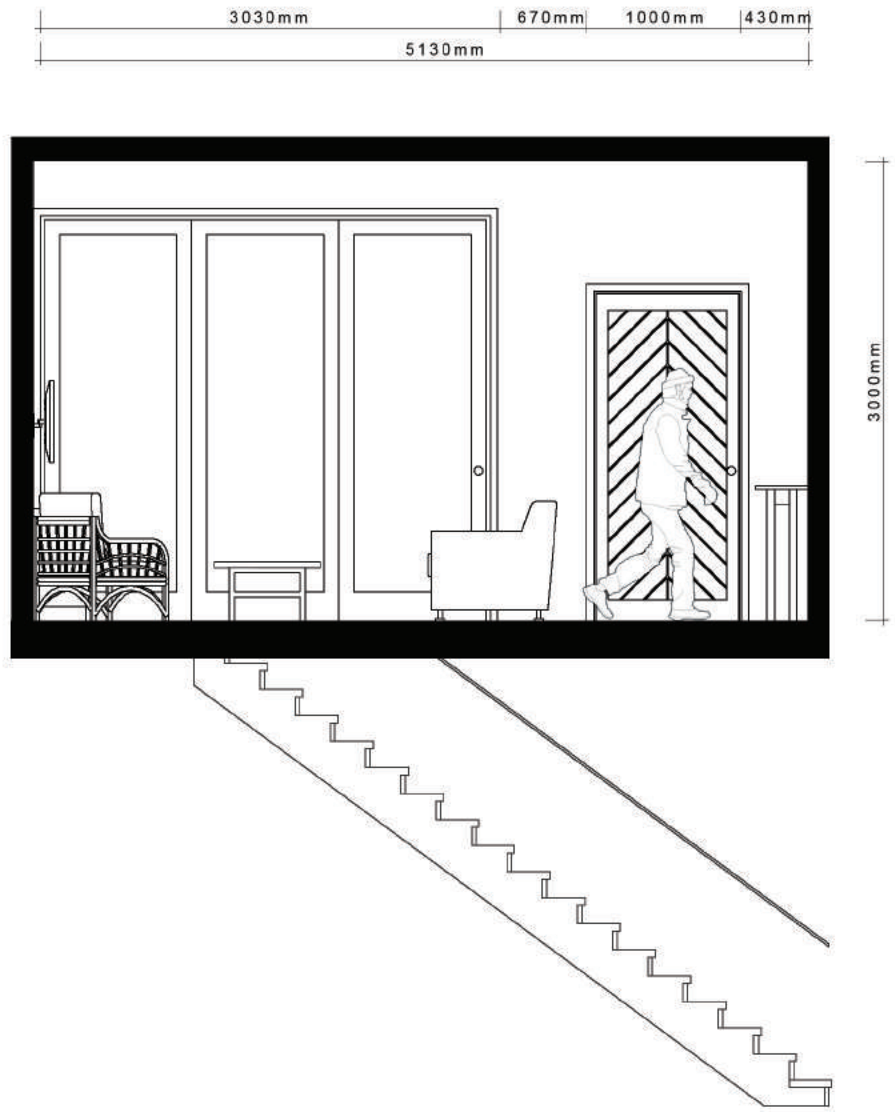


LIVING ROOM AND BALCONY FINISHED WITH HARDWOOD FLOORS TO CREATE A SEAMLESS TRANSITION FROM INTERIOR TO EXTERIOR.

HERINGBONE TIMBER DOORS AND TIMBER FRAMED GLAZED SLIDING DOORS.

LIVING SPACE OPEN PLAN TO BE CUSTOMISABLE TO CLIENTS NEEDS.

1 BEDROOM MODULE



BEDROOMS CAN BE CUSTOMISED TO THE CLIENTS COLOUR NEEDS

LIGHT FITTINGS FOR BEDSIDE PENDANT LIGHTS ARE CHASED INTO THE CELING BUT TO BE DECIDIED BY CLIENT.

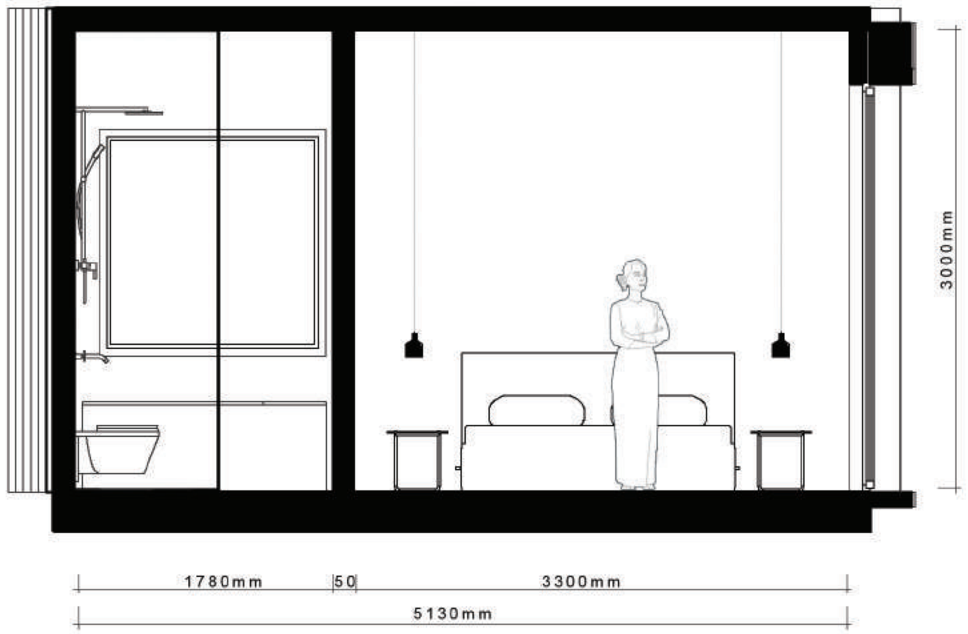
BATHROOM FITTED WITH TIMBER LOOK MELAMINE CABINETS AND MATTE BLACK CABINET PULLS.

MATTE BLACK SHOWERHEAD AND TAPWARE,

CERAMIC FREESTANDING BATHTUB WITH BLACK FRAMED GLASS SCREEN

BATHROM WINDOW FITTED WITH PULL DOWN BLIND OR CAN BE TINTED FOR PRIVACY PURPOSES.

BEDROOM & BATHROOM



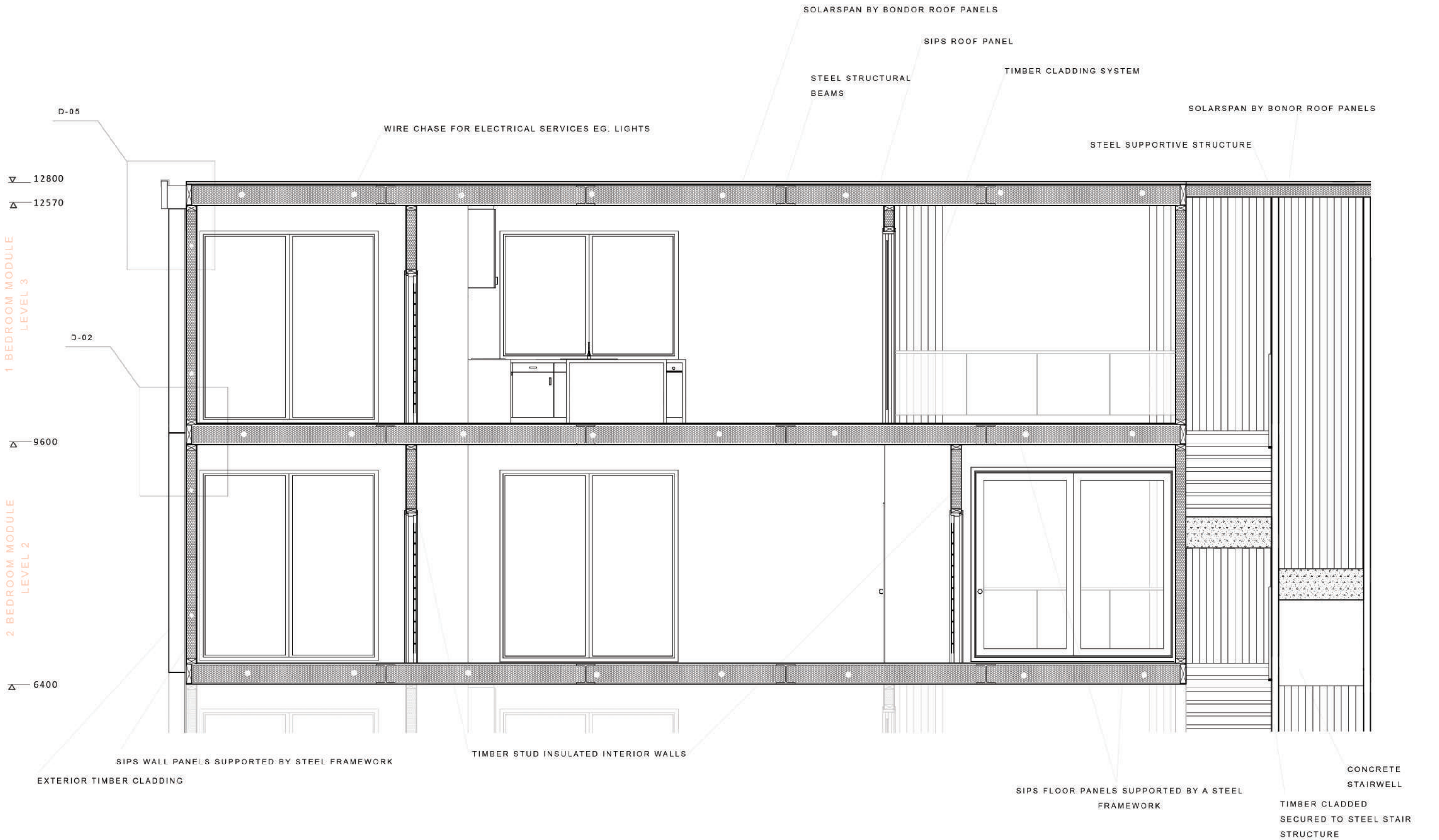
[redacted]

Unit: Integrated Buildings Research Methods and Studio 2020
Project name: FLEETWOOD MODULAR PROJECT
Site: Melbourne
Description: Affordable and movable modular housing complex consisting of 10x 2 bedroom modules and 4x 1 bedroom modules.

INTERIOR ELEVATIONS

2 BEDROOM MODULE [KITCHEN & DINING], BEDROOM & BATHROOM AND 1 BEDROOM MODULE [LIVING & ENTRY]
1:50 @ A3

18/06/2020



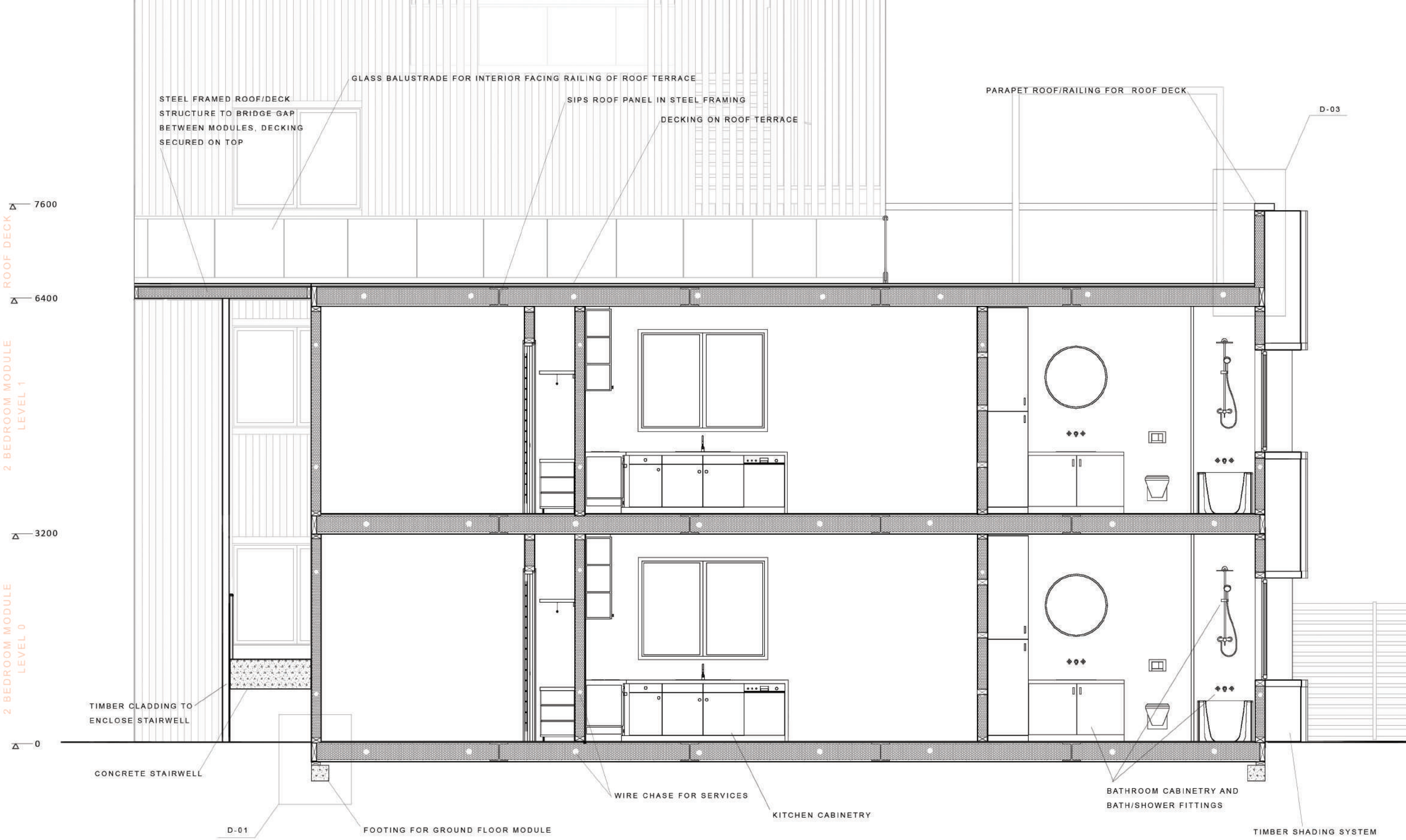
[redacted]

Unit: Integrated Buildings Research Methods and Studio 2020
Project name: FLEETWOOD MODULAR PROJECT
Site: Melbourne
Description: Affordable and movable modular housing complex consisting of 10x 2 bedroom modules and 4x 1 bedroom modules.

SECTION 1

LEVEL 2 (2 BEDROOM), LEVEL 3 (1 BEDROOM) TO ROOF
1:50 @ A3

18/06/2020

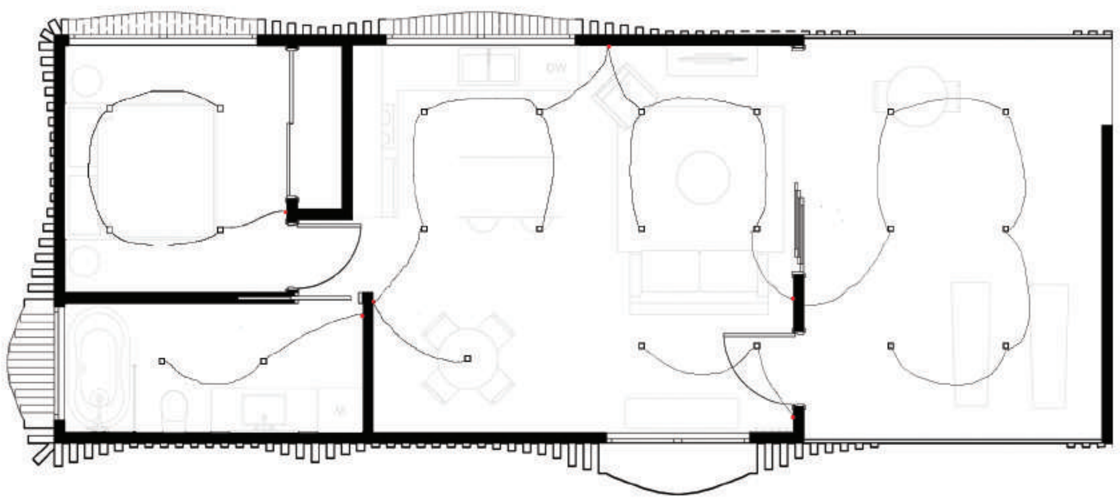


[redacted]

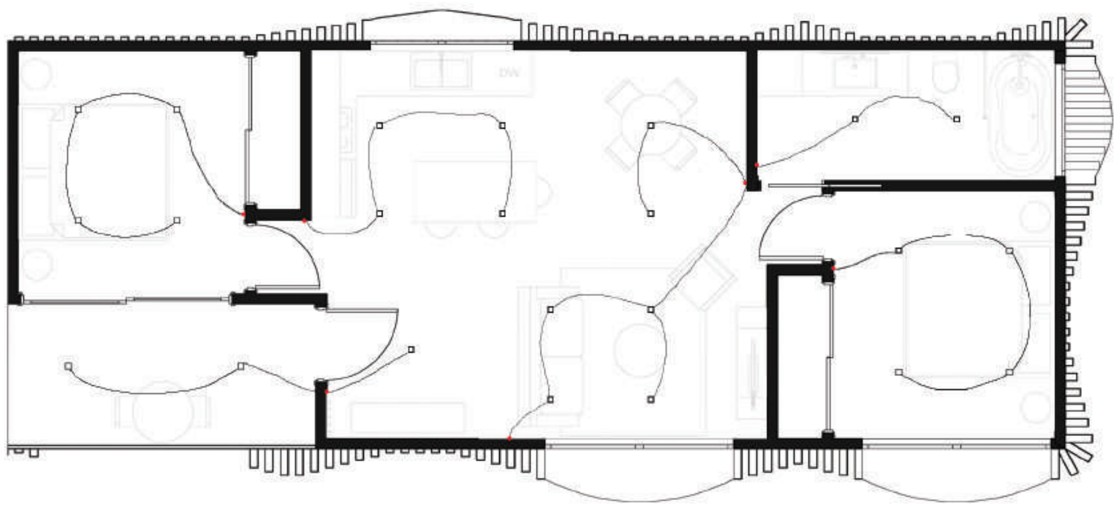
Unit: Integrated Buildings Research Methods and Studio 2020
Project name: FLEETWOOD MODULAR PROJECT
Site: Melbourne
Description: Affordable and movable modular housing complex consisting of 10x 2 bedroom modules and 4x 1 bedroom modules.

SECTION 2
GROUND FLOOR TO FIRST FLOOR AND ROOF DECK
1:50 @ A3

18/06/2020



1 BEDROOM LIGHTING PLAN



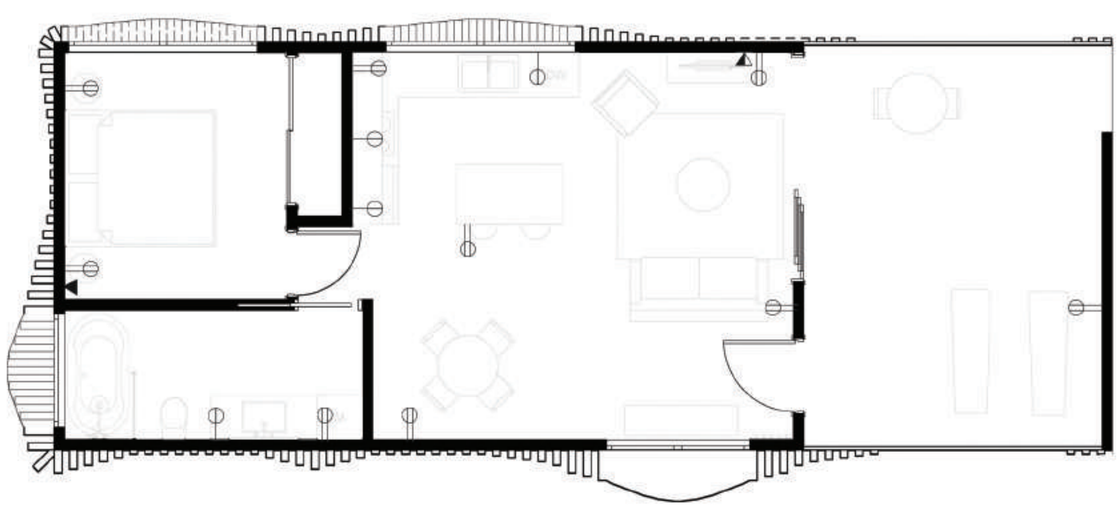
2 BEDROOM LIGHTING PLAN

[redacted]

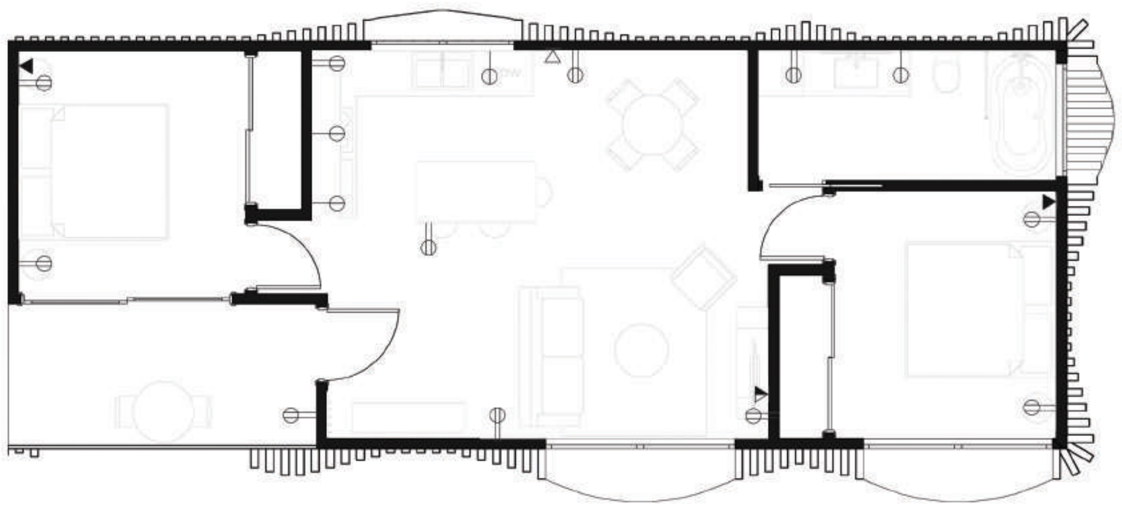
Unit: Integrated Buildings Research Methods and Studio 2020
Project name: FLEETWOOD MODULAR PROJECT
Site: Melbourne
Description: Affordable and movable modular housing complex consisting of 10x 2 bedroom modules and 4x 1 bedroom modules.

REFLECTED CEILING PLAN
1 BEDROOM & 2 BEDROOM MODULES
1:100 @ A3

18/06/2020



1 BEDROOM POWER & DATA PLAN



2 BEDROOM POWER & DATA PLAN

LEGEND

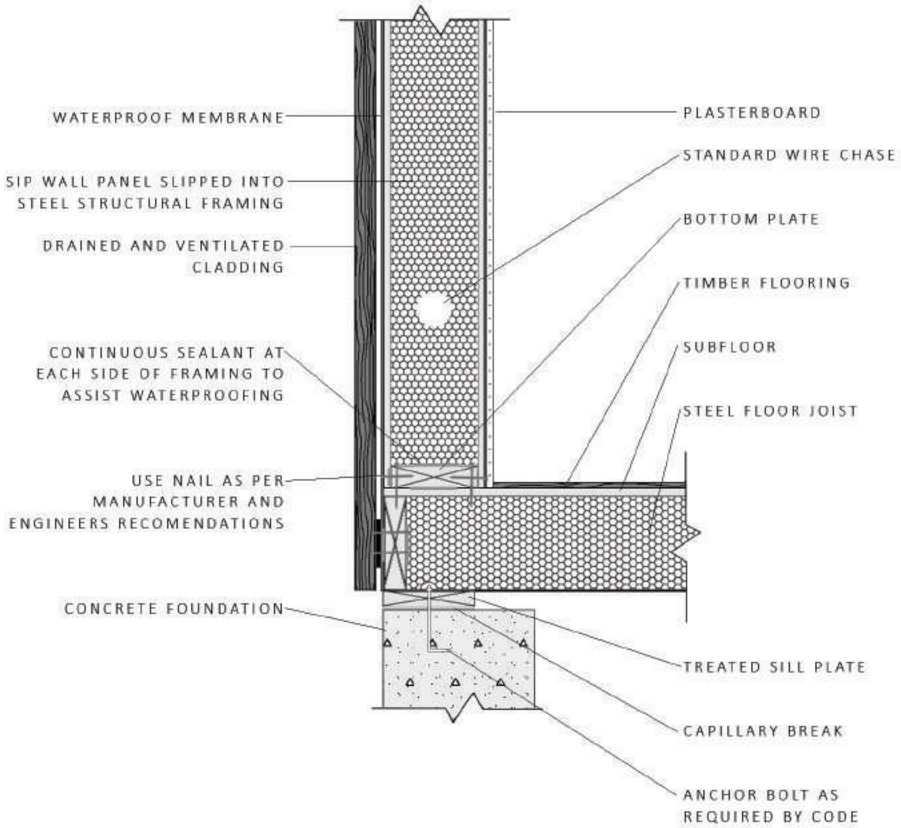
- SINGLE OUTLET
- DUPLEX OUTLET
- TELEPHONE OUTLET
- DATA OUTLET
- DATA/TELEPHONE OUTLET

[redacted]

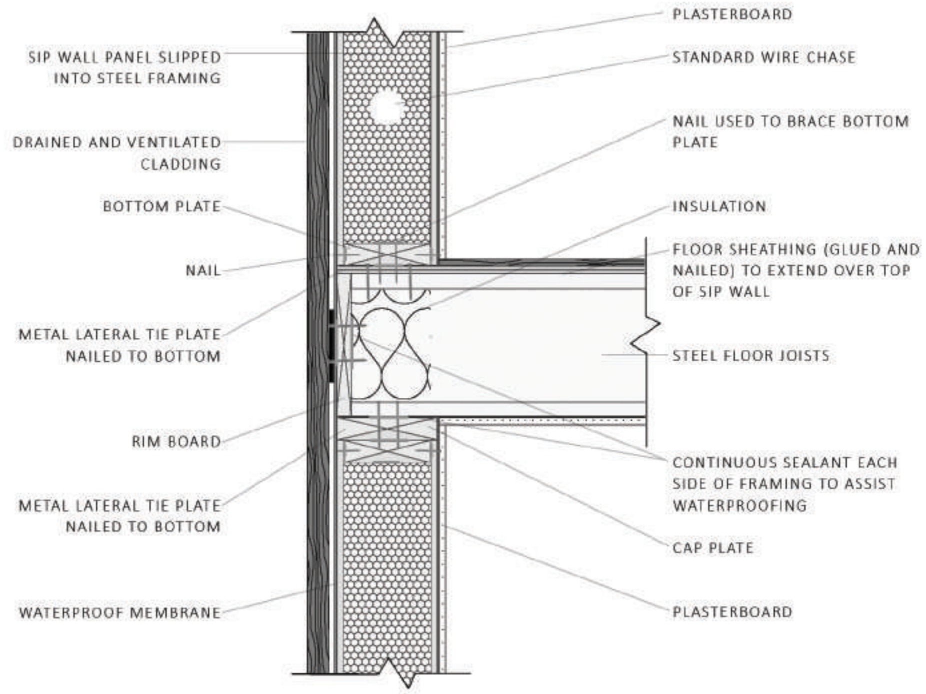
Unit: Integrated Buildings Research Methods and Studio 2020
Project name: FLEETWOOD MODULAR PROJECT
Site: Melbourne
Description: Affordable and movable modular housing complex consisting of 10x 2 bedroom modules and 4x 1 bedroom modules.

POWER AND DATA PLAN
1 BEDROOM & 2 BEDROOM MODULES
1:100 @ A3

18/06/2020



FOUNDATION CONNECTION DETAIL
D-01



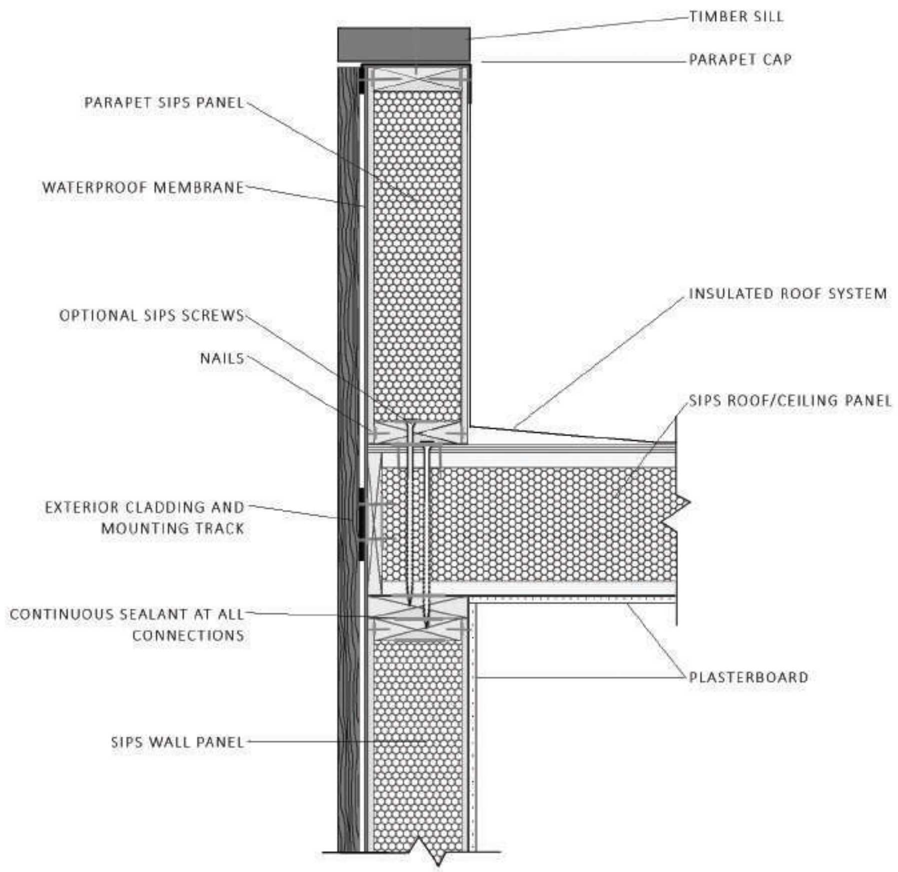
UPPER FLOOR CONNECTION DETAILS
D-02

[redacted]

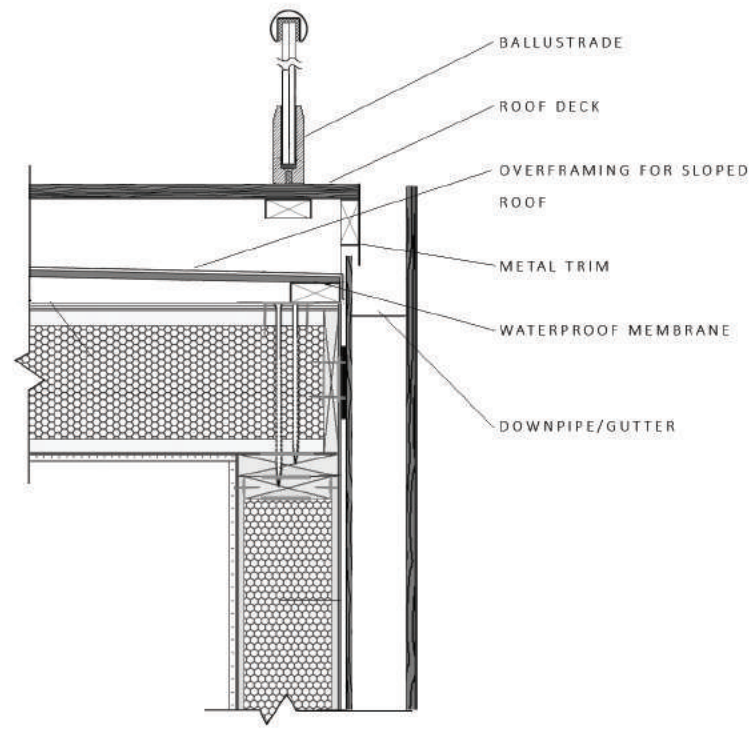
Unit: Integrated Buildings Research Methods and Studio 2020
Project name: FLEETWOOD MODULAR PROJECT
Site: Melbourne
Description: Affordable and movable modular housing complex consisting of 10x 2 bedroom modules and 4x 1 bedroom modules.

DETAILS
WALL TO FLOOR (D-01), UPPER FLOOR CONNECTION (D-02)
1:10 @ A3

18/06/2020



PARAPET ROOF/ROOF DECK DETAIL
D-03



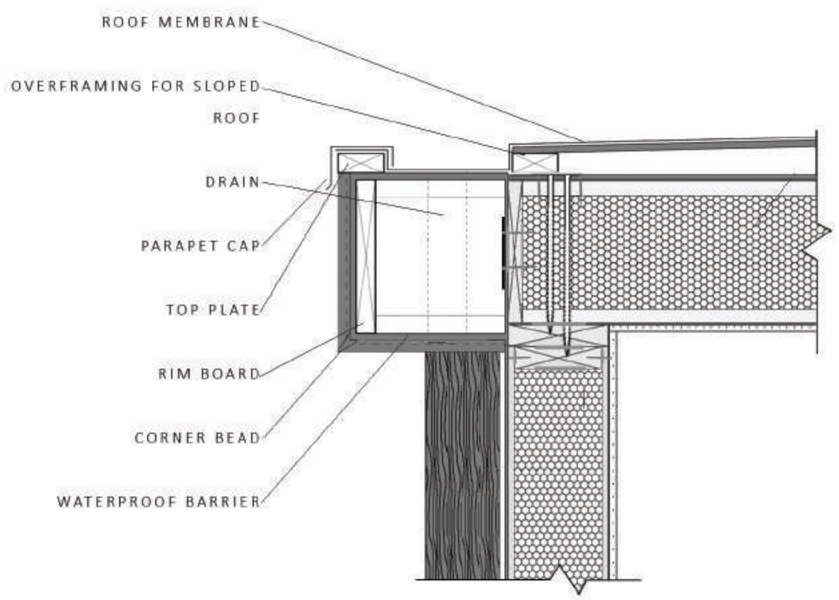
ROOF DECK TO GUTTER DETAIL
D-04

[redacted]

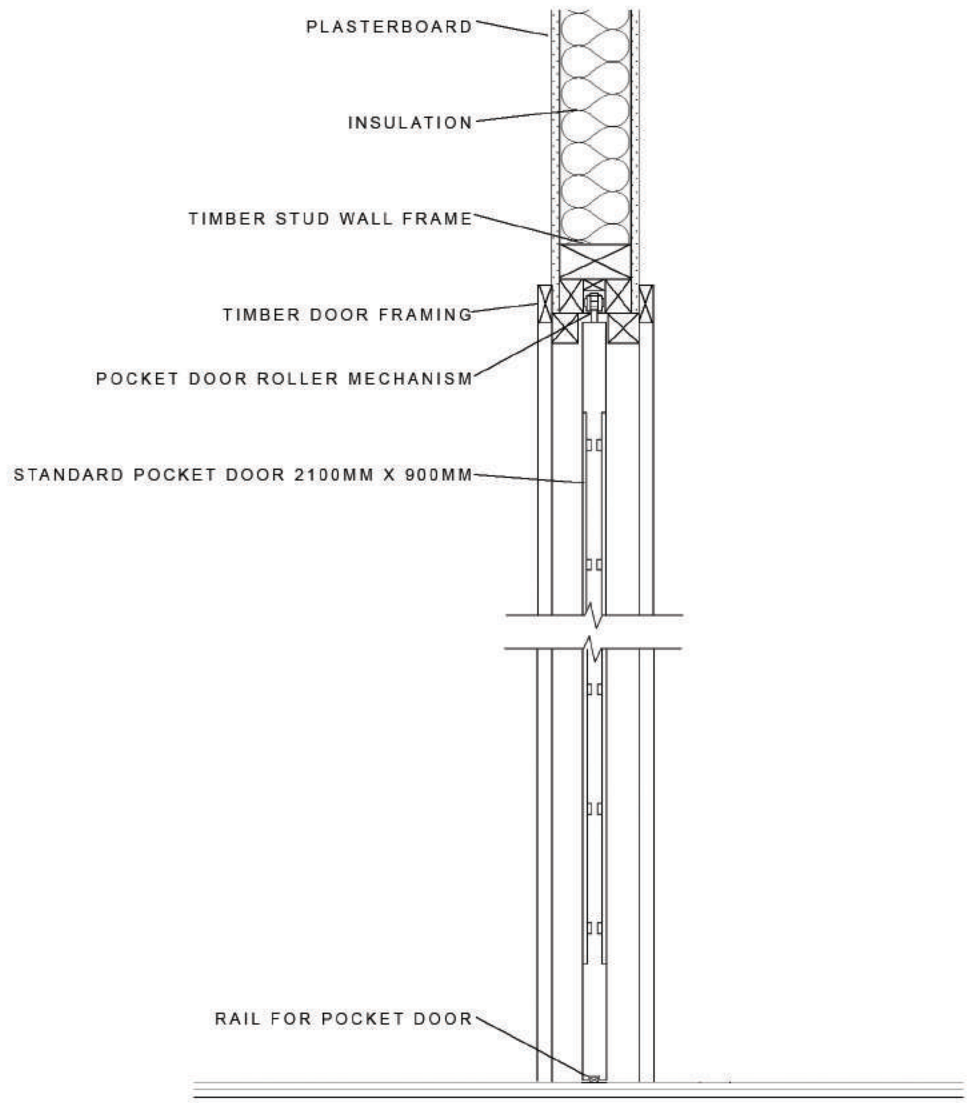
Unit: Integrated Buildings Research Methods and Studio 2020
Project name: FLEETWOOD MODULAR PROJECT
Site: Melbourne
Description: Affordable and movable modular housing complex consisting of 10x 2 bedroom modules and 4x 1 bedroom modules.

DETAILS
PARAPET ROOF/ROOF DECK (D-03), ROOF DECK TO GUTTER (D-04)
1:10 @ A3

18/06/2020



BOX GUTTER DETAIL
D-05



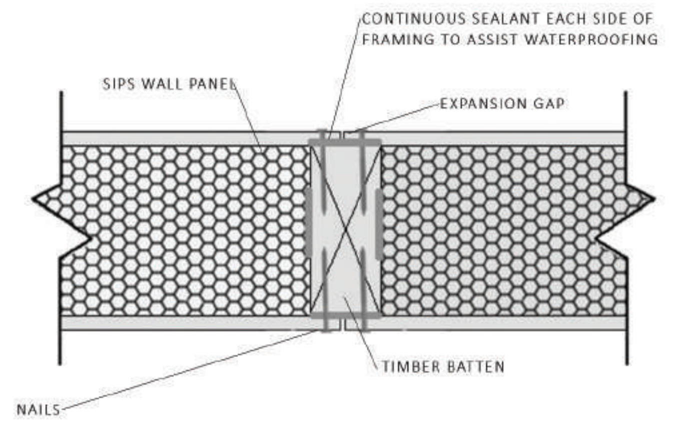
DOOR DETAIL
D-06

[redacted]

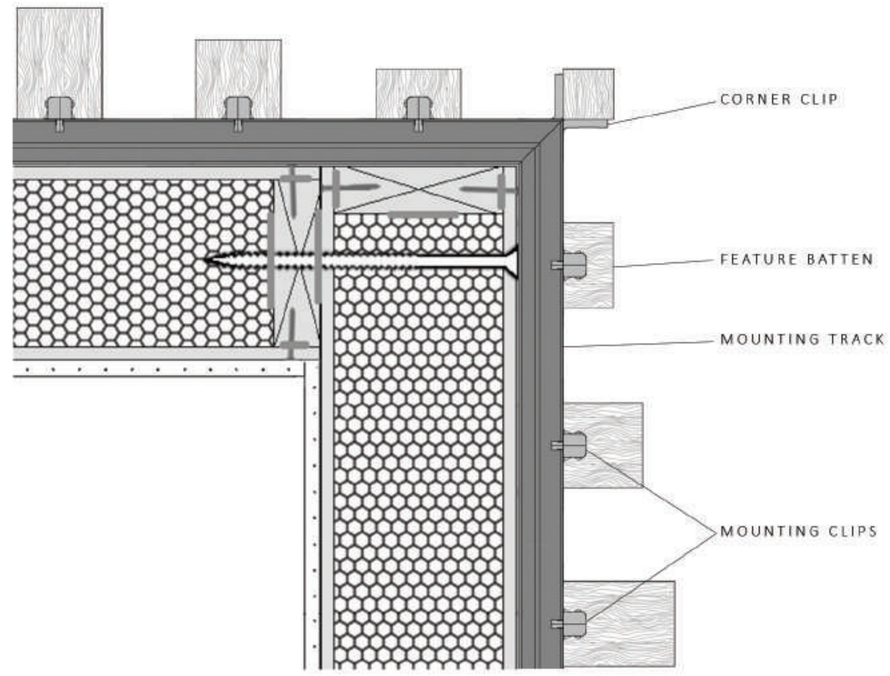
Unit: Integrated Buildings Research Methods and Studio 2020
Project name: FLEETWOOD MODULAR PROJECT
Site: Melbourne
Description: Affordable and movable modular housing complex consisting of 10x 2 bedroom modules and 4x 1 bedroom modules.

DETAILS
BOX GUTTER (D-05), BATHROOM POCKET DOOR (D-06)
1:10 @ A3

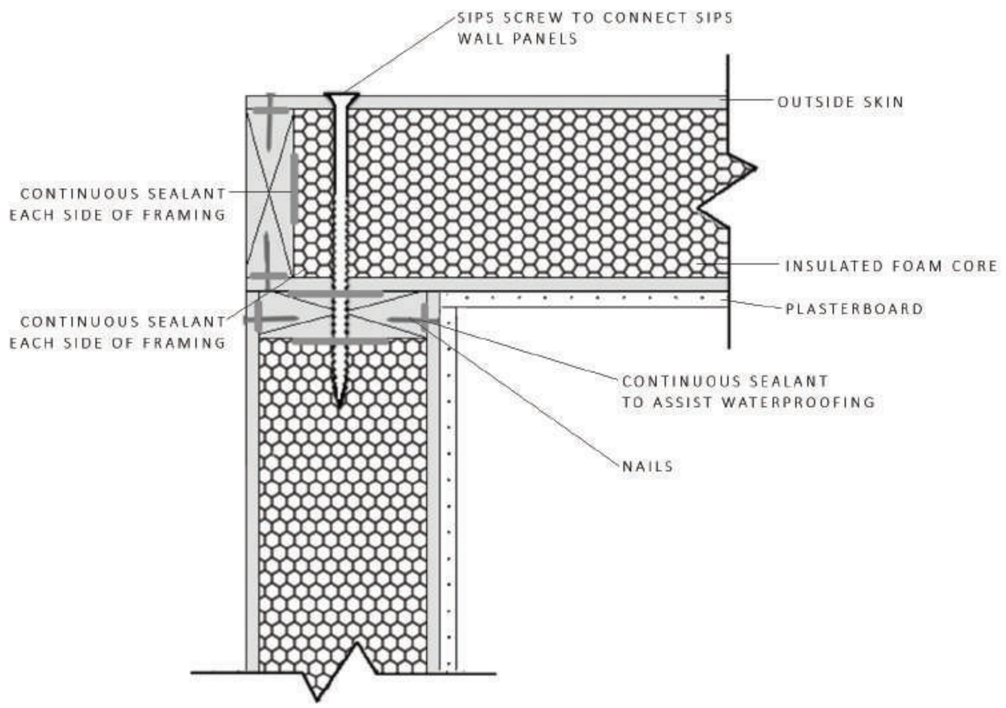
18/06/2020



WALL CONNECTION VERTICAL SPLICE
D-09



CORNER WALL WITH EXTERIOR SHADING SYSTEM
D-11



CORNER WALL CONNECTION
D-10

[redacted]

Unit: Integrated Buildings Research Methods and Studio 2020
Project name: FLEETWOOD MODULAR PROJECT
Site: Melbourne
Description: Affordable and movable modular housing complex consisting of 10x 2 bedroom modules and 4x 1 bedroom modules.

DETAILS
WALL TO WALL SPLINE CONNECTION (D-09), WALL TO WALL CORNER CONNECTION (D-10) & WALL TO EXTERIOR SHADING SYSTEM (D-11)
1:20 @ A3
18/06/2020

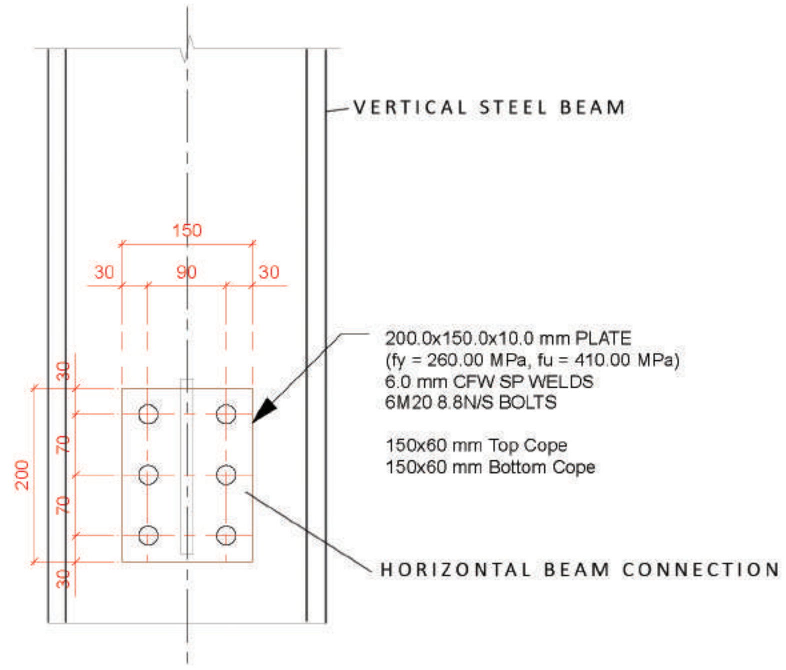


PLATE CONNECTION (SECTION)
VERTICAL BEAM TO HORIZONTAL BEAM
D-12

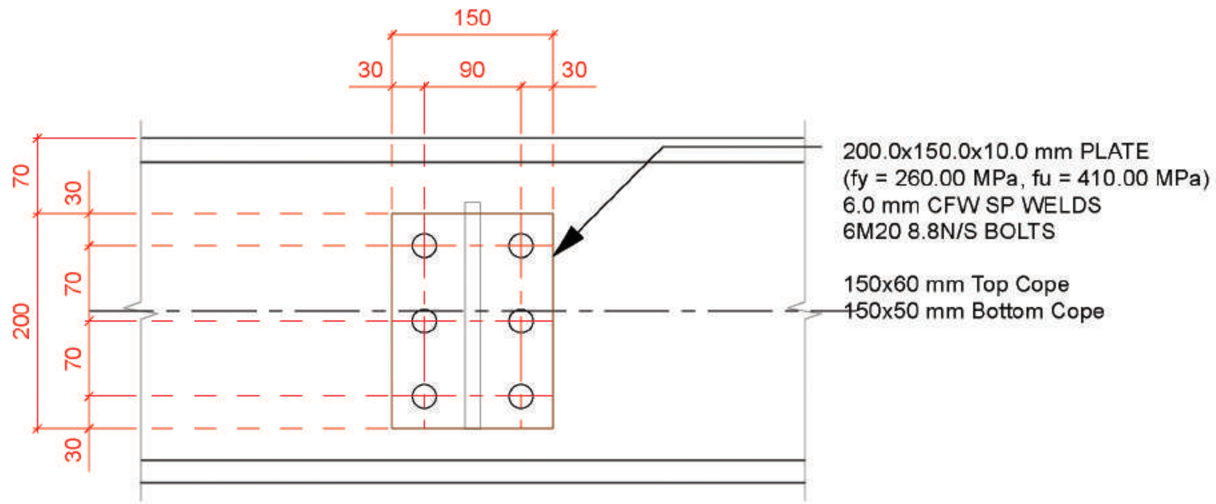


PLATE CONNECTION (SECTION)
HORIZONTAL BEAM TO FLOOR JOISTS FOR SIPS WALL PANELS
D-14

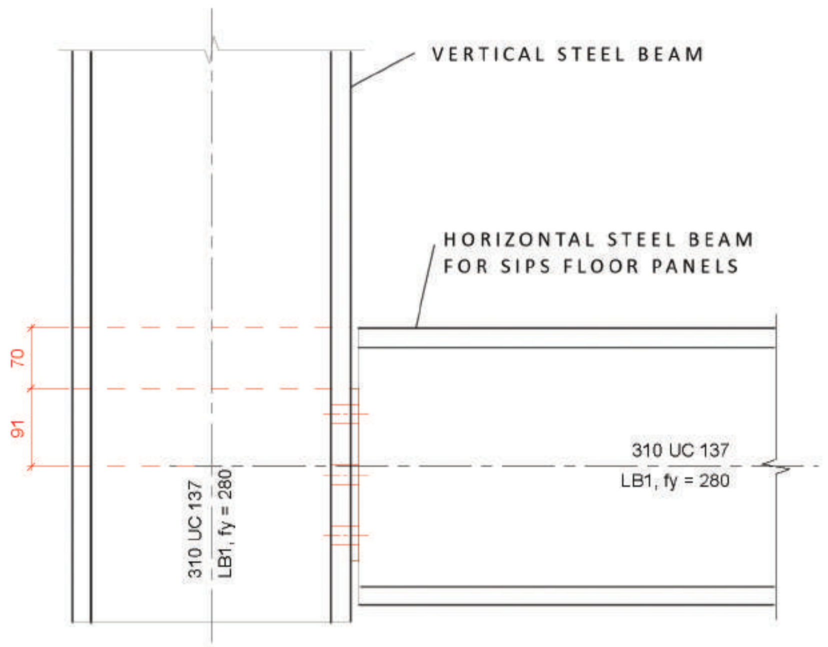


PLATE CONNECTION (SECTION)
VERTICAL BEAM TO HORIZONTAL FLOOR JOISTS FOR SIPS WALL PANELS
D-13

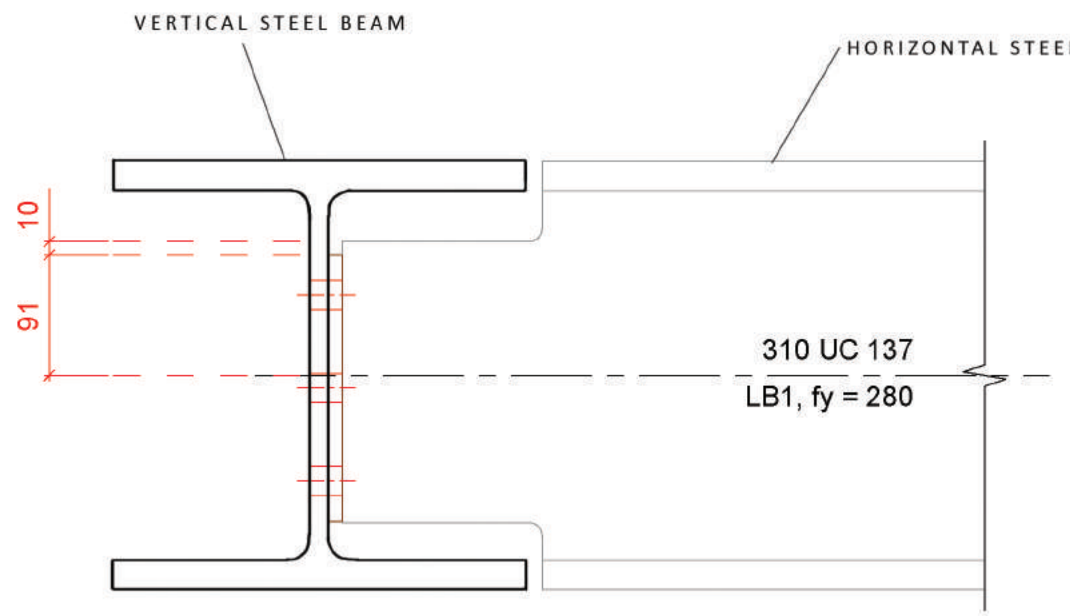
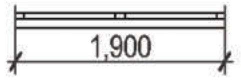
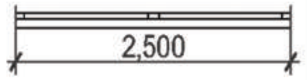
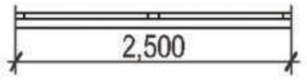
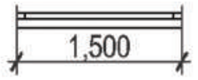
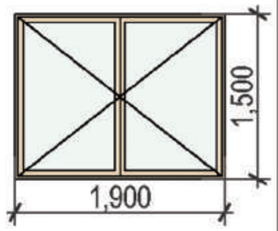
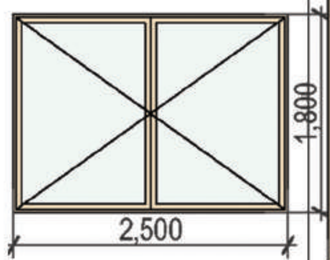
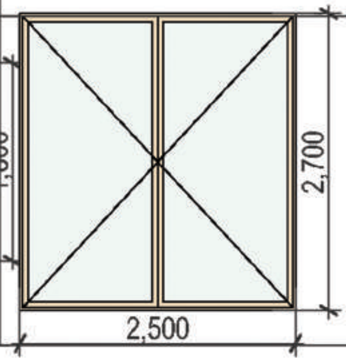
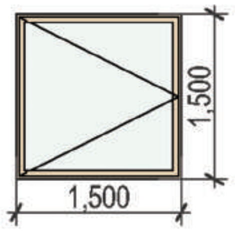


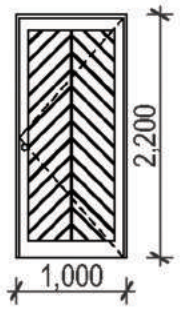
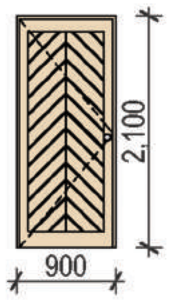
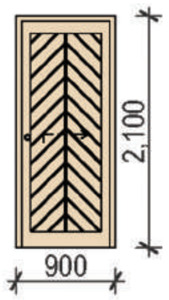
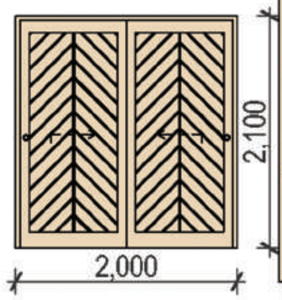
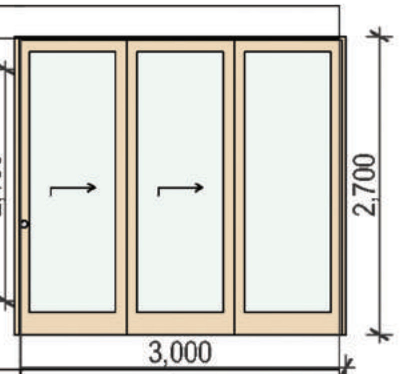
PLATE CONNECTION (PLAN)
VERTICAL BEAM TO HORIZONTAL BEAM
D-15

[redacted]

Unit: Integrated Buildings Research Methods and Studio 2020
Project name: FLEETWOOD MODULAR PROJECT
Site: Melbourne
Description: Affordable and movable modular housing complex consisting of 10x 2 bedroom modules and 4x 1 bedroom modules.

DETAILS [PLATE CONNECTION FOR SKELETAL STRUCTURE]
V. TO H. BEAMS (D-12), FLOOR JOISTS (D-13), FLOOR JOISTS (D-014) & V. TO H. BEAMS (D-15)
1:10 @ A3
18/06/2020

WINDOW SCHEDULE				
NAME	Double Sash Window 20	Double Sash Window 20	Double Sash Window 20	Window 20
ID	W-01	W-0 2	W-03	W-04
FROM	Living Room	Kitchen	Bedroom	Bathroom
W x H	1,900x1,500	2,500x1,800	2,500x2,700	1,500x1,500
SILL HEIGHT	1,200	900	0	900
HEAD HEIGHT	2,700	2,700	2,700	2,400
2D				
ELEVATION				

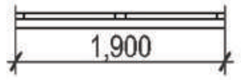
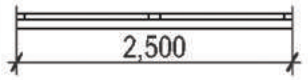
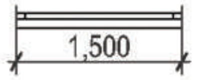
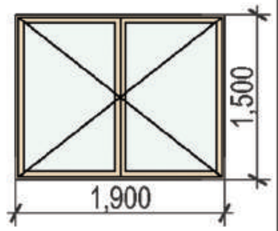
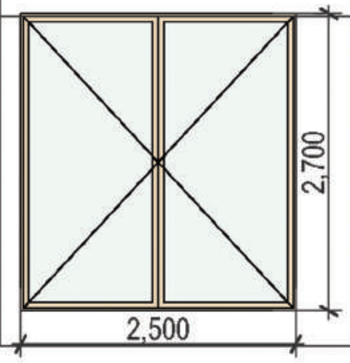
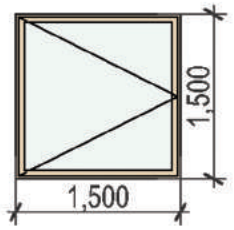
DOOR SCHEDULE					
					
NAME	Door 20	Door 20	Pocket Door 20	Sliding Door 20	Sliding Door 20
ID	D-01	D-02	D-03	D- 04	D- 05
FROM	Entry	Bedroom	Bathroom	Bedroom	Living Room
W x H	1,000x2,200	900x2,100	900x2,100	2,000x2,100	3,000x2,700
COMMENTS					

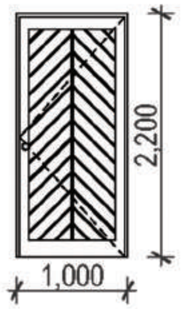
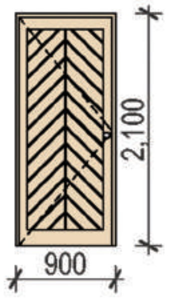
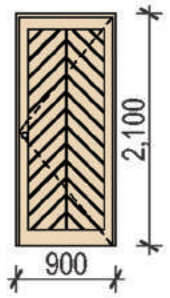
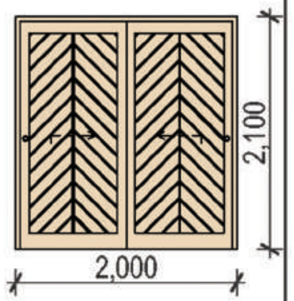
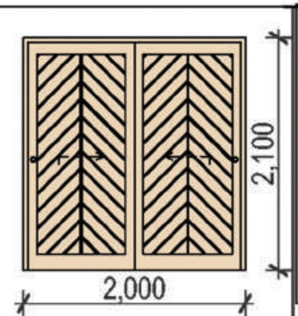
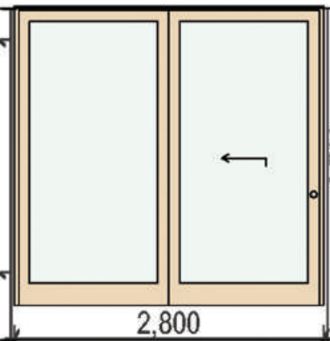
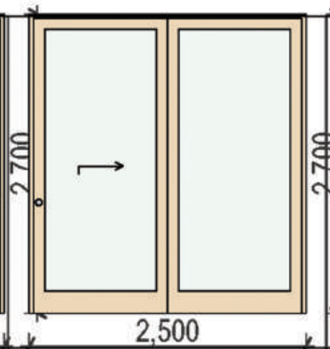
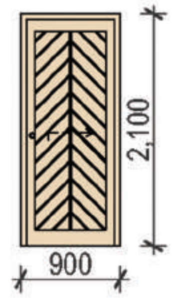
[redacted]

Unit: Integrated Buildings Research Methods and Studio 2020
Project name: FLEETWOOD MODULAR PROJECT
Site: Melbourne
Description: Affordable and movable modular housing complex consisting of 10x 2 bedroom modules and 4x 1 bedroom modules.

DOOR & WINDOW SCHEDULE
[1 BEDROOM MODULE]
@ A3

18/06/2020

WINDOW SCHEDULE			
NAME	Double Sash Window 20	Double Sash Window 20	Window 20
ID	W-01	W-0 2	W-03
FROM	Kitchen	Bedroom 2	Bathroom
W x H	1,900x1,500	2,500x2,700	1,500x1,500
SILL HEIGHT	1,200	0	900
HEAD HEIGHT	2,700	2,700	2,400
2D			
ELEVATION			

DOOR SCHEDULE								
								
NAME	Door 20	Door 20	Door 20	Sliding Door 20	Sliding Door 20	Sliding Door 20	Sliding Door 20	Pocket Door 20
ID	D-01	D-02	D-03	D-04	D-05	D- 06	D- 07	D- 08
FROM	Entry	Bedroom 1	Bedroom 2	Bedroom 1	Bedroom 2	Bedroom 1	Living Room	Bathroom
W x H	1,000x2,200	900x2,100	900x2,100	2,000x2,100	2,000x2,100	2,800x2,700	2,500x2,700	900x2,100
COMMENTS								

[redacted]

Unit: Integrated Buildings Research Methods and Studio 2020
Project name: FLEETWOOD MODULAR PROJECT
Site: Melbourne
Description: Affordable and movable modular housing complex consisting of 10x 2 bedroom modules and 4x 1 bedroom modules.

WINDOW & DOOR SCHEDULE
[2 BEDROOM MODULE]
@ A3

18/06/2020

LIFE CYCLE COSTING:

LIFE CYCLE STAGE	DETAIL DESCRIPTION	CODE	AUD $	OZONE DEPLETION POTENTIAL, ODP (KG CFC-11 eq)	EMBODIED ENERGY (MJ NCV)	GLOBAL WARMING POTENTIAL (kg CO2 eq)
MATERIAL AND CONSTRUCTION STAGE	PRODUCT STAGE	A1-A3	347,843	-0.5427	18,241.9081	-17,098.354
	TRANSPORT OF EQUIPMENT AND MATERIALS	A4	32,020	2,117.4426	6,345.9394	15,198.034
	CONSTRUCTION	A5	8,681	236.8058	1,036.4298	8,123.670
USE STAGE	USE OF PRODUCTS	B1	0	0.0000	0.0000	0.000
	MAINTENANCE	B2	0	0.0000	0.0000	0.000
	REPAIR	B3	0	0.0000	0.0000	0.000
	REPLACEMENT	B4	3,197	57.3847	35,787.0900	2,987.034
	REFURBISHMENT	B5	0	0.0000	0.0000	0.000
	INTEGRATED OPERATIONAL ENERGY USE	B6	4,050	1.0746	60.1213	3,489.930
	OTHER OPERATIONAL ENERGY USE	B6+	5,056	19.8684	97,392.0092	12,908.039
	OPERATIONAL WATER USE	B7	0	0.0000	0.0000	0.000
END OF LIFE STAGE	DECONSTRUCTION/DEMOLITION	C1	0	0.0000	0.0000	0.000
	TRANSPORT OF WASTE OFF SITE	C2	840	13.0981	12.0928	678.187
	WASTE PROCESSING	C3	0	0.0203	0.0923	0.056
	DISPOSAL	C4	3,842	120.4187	109.0928	20,980.093
BENEFITS AND LOADS BEYOND THE SYSTEM BOUNDARY	OPERATIONAL ENERGY EXPORTS	D1	0	0.0000	0.0000	0.000
	CLOSE LOOP RECYCLING	D2	0	-0.9002	-8,9800.0812	-323.392
	OPEN LOOP RECYCLING	D3	0	0.1089	32.2321	4.329
	MATERIAL ENERGY RECOVERY	D4	0	0.9852	18,299.3292	103.786
	DIRECT RE-USE	D5	0	0.000	0.0000	0.000
		TOTAL:	405,529	2,565.7644	87,516.3559	47,051.412

ESTIMATE SUMMARY OF TRADES COST
(NOT INCLUDING MATERIALS)

	$		SQM	RATE
TRADE TOTAL				
PRELIMINARIES				
CLEAR SITE OF VEGETATION	$	512.00	1024	0.5
LEVEL SOIL	$	1,945.60	1024	1.9
SITEWORKS				
CONCRETE STRIP FOOTINGS	$	5,200.00	26	200
SIPS PANELS	$	21,252.00	506	42
TIMBER STUDS	$	2,400.00	80	30
JOINERY OF MODULES (CRANE)	$		6 MODULES	
FAÇADE SYSTEM & SUN SHADING	$	5,060.00	506	10
PAVING	$	5,720.00	220	26
ROOF COVER & ROOF PLUMBER	$	1,209.60	302.4	4
PRE-FABRICATED (OFF-SITE CONSTRUCTION):				
PLUMBER	$	2,000.00		
ELECTRICIAL	$	2,000.00		
PLASTERER	$	2,000.00		
CEILING	$	500.00		
TILING	$	1,000.00		
GLASS	$	2,000.00		
PAINT	$	2,000.00		
GAS	$	1,000.00		
NET PROJECT TOTAL	$	55,799.20		
OVERHEADS & PROFIT: 10%				
SUB_TOTAL				
G.S.T. 10%				
GROSS ESTIMATE				

ESTIMATE ANALYSIS

Area

House

Verandah

302.40 m2

TOTAL TRADE COST FOR PROJECT = $ 55,799.20 / 302.40 m2

= $ 184.52 per m2

INTERIOR DESIGN

2 BEDROOM MODULE:

The 2-bedroom module has a well-designed kitchen that fits seating for 3-4-people at the island (pictured above). This kitchen design allows ample bench space as well as room for a double fridge, dishwasher and double sink. Located next to the kitchen is the dining area that can fit a 4-6-person dining table and chairs. The kitchen window has a view into the private courtyard whilst the living room has floor to ceiling windows with views to the outdoor garden (pictured below). The floor to ceiling sliding door is made of timber, varnished and sealed, to match the exterior cladding. Interior finishes are entirely customisable in colour.

The 2-bedroom modules located on the ground floor have direct access via sliding doors to private garden spaces (pictured above). Perfect for families or people with pets, they are spacious gardens that almost match the square footage of the unit. For 2-bedroom units located on the first floor and above, they have a small private balcony area that meets building code (pictured below). One of the two bedrooms has doubled sliding doors that open onto the balcony which is protected from the weather via the roof terrace and timber cladding system. The entirety of all the 2-bedroom modules will have hardwood vinyl floors that run throughout the entire unit. They are waterproof, scratch resistant and have the look and feel of real timber. These were a great choice as they are more durable and water resistant so can be utilised in wet areas like the bathroom and kitchen and outdoor areas that will be open to the elements like the balcony.

1 BEDROOM MODULE:

The 1-bedroom module has a large living area that opens onto a private terrace space via sliding doors. The spacious balcony is sheltered via the module above and timber cladding allowing for protection from the elements whilst also allowing optimal winter sun. The 1-bedroom unit also has continuous vinyl floors throughout to provide a durable, cost effective and lighter alternative to real timber floors. This allows a seamless transition from interior to out.

BEDROOMS:

With the potential of these modular homes housing small families, I have designed a room to accommodate the needs of a parent with a small child. The rooms can fit a cot, change table and breast-feeding chair comfortably as well as having double sliding door built in storage. The bedrooms can also fit a queen bed comfortably with bedside tables. The ground floor modules have direct access to their own garden via sliding doors that open onto the ‘balcony’ and garden spaces.

BATHROOM:

The bathroom is spacious with a beautiful free-standing bathtub, waterfall showerhead, floating toilet and vanity. The bathroom also serves as the laundry room with a washer/dryer hidden in the floor to ceiling cabinetry. This cupboard is ideal for vacuums, mops and other cleaning items as well as a dual washer/dryer unit. This saves space in the rest of the home for liveable spaces. All units have timber look cabinetry, matte black fixtures and stone countertops.

COURTYARD/CIRCULATION SPACE

The exterior cladding continues to the courtyard of the building too. With a small grassed area and tree, this area is the circulation hub for the complex. This design allowed for private access to the units that wasn't directly off the main street. It also, because of the configuration of the units, gets optimal winter sun (as pictured above), so it isn't dark and cold in winter

ROOF DECK

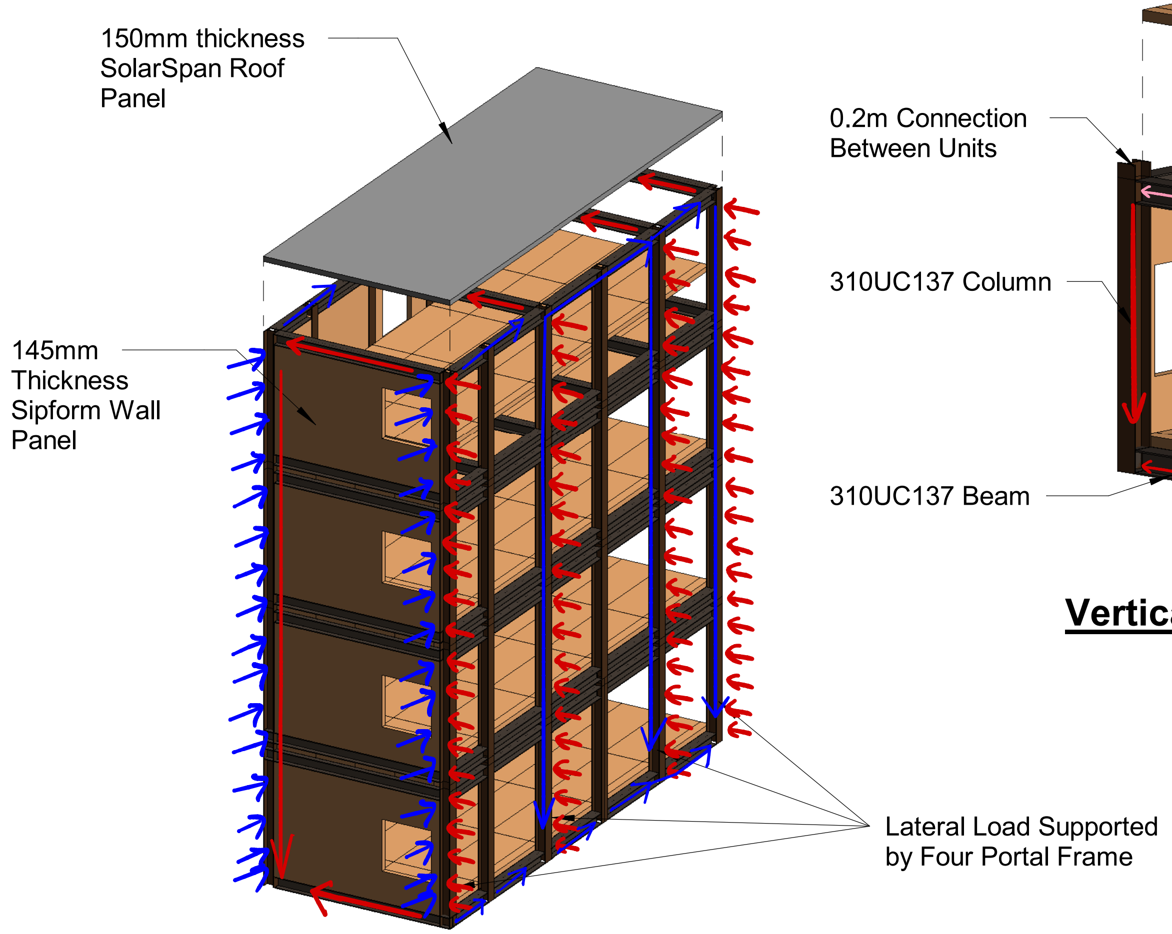
The roof deck expands over the roof of 2 modules optimising the area of the site. Open to everyone in the complex, the roof deck takes advantage of winter sun and Melbourne's view. The interior balustrade is made of glass, allowing light to reach the courtyard, whilst the exterior balustrades are a parapet to allow privacy from the street.

ENGINEERING DRAWINGS

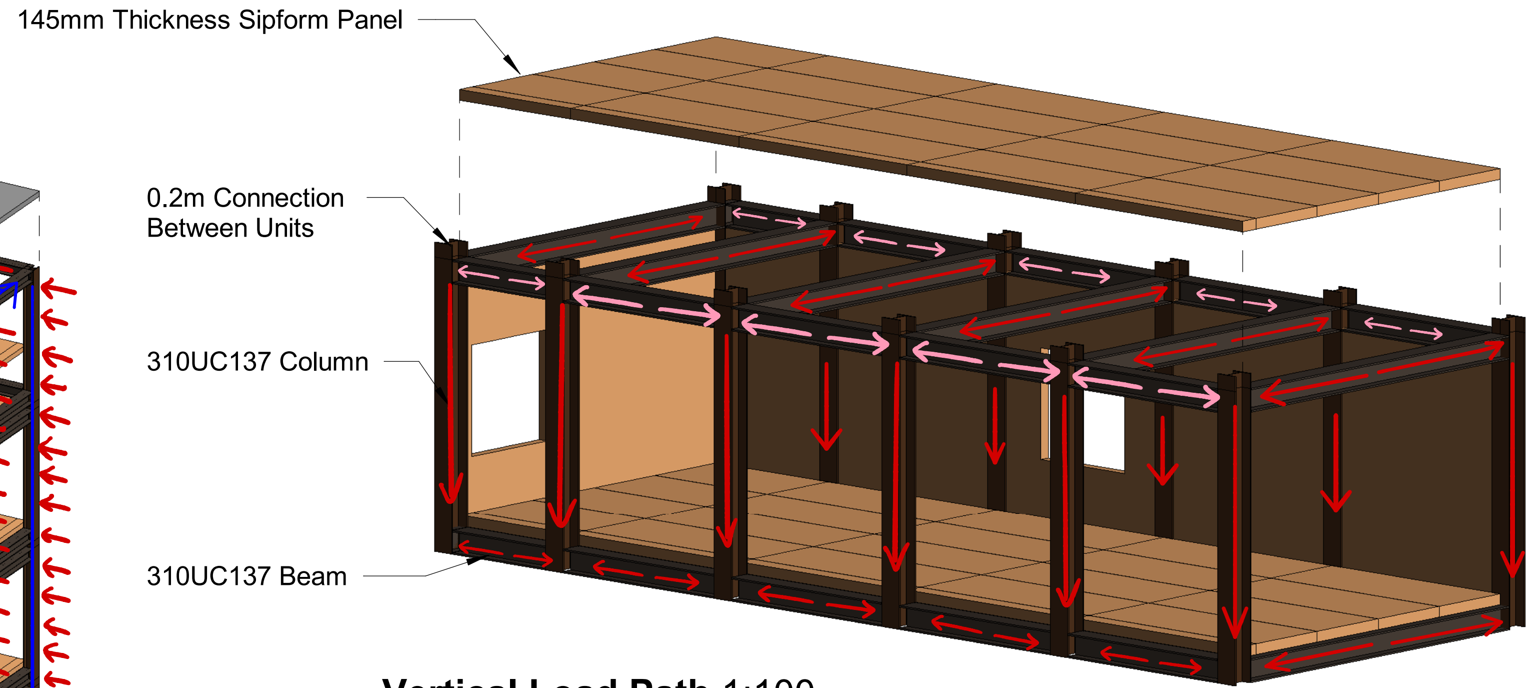
Table of Contents

List of Figures

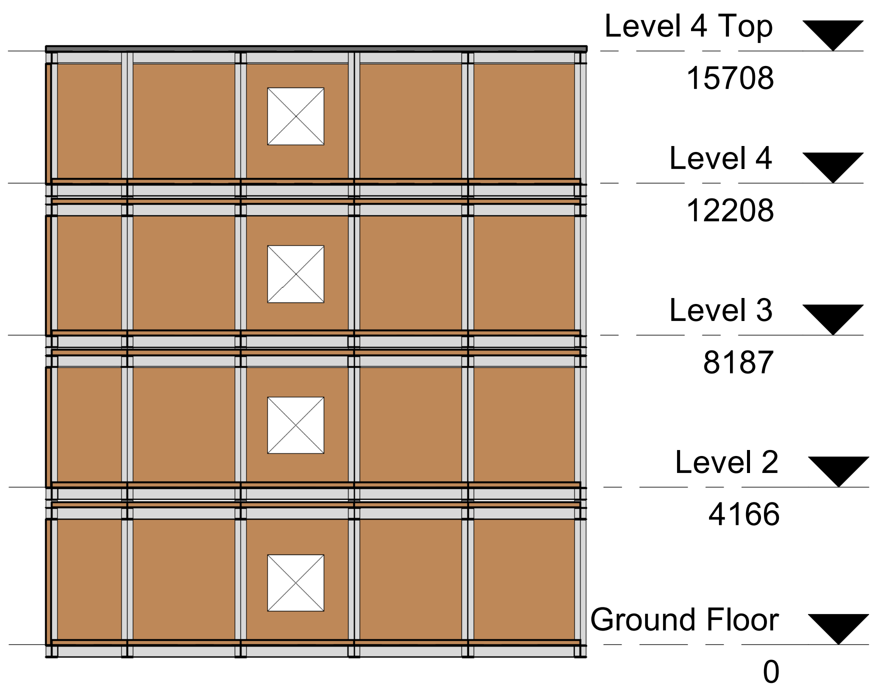
List of Tables



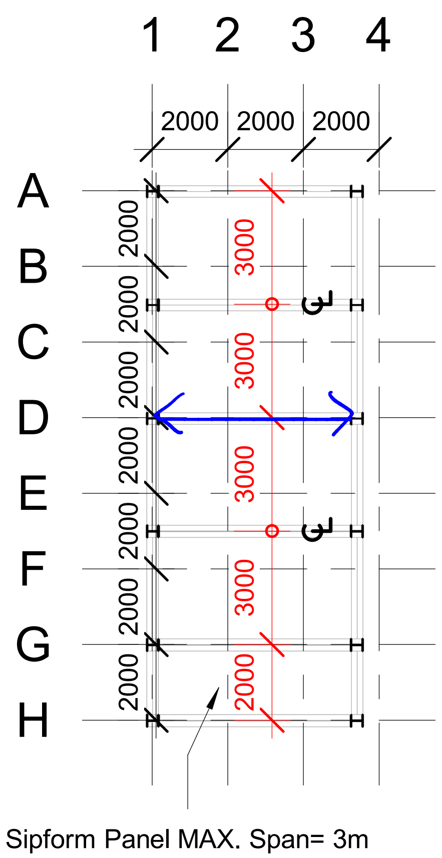
Lateral Load Path 1:200



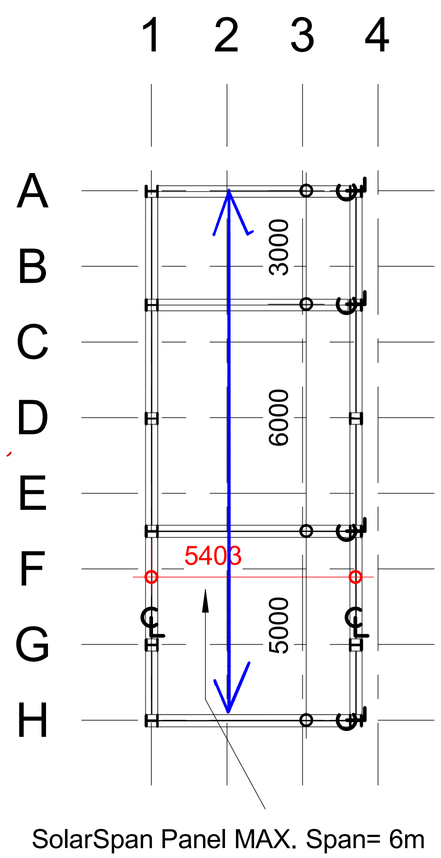
Vertical Load Path 1:100



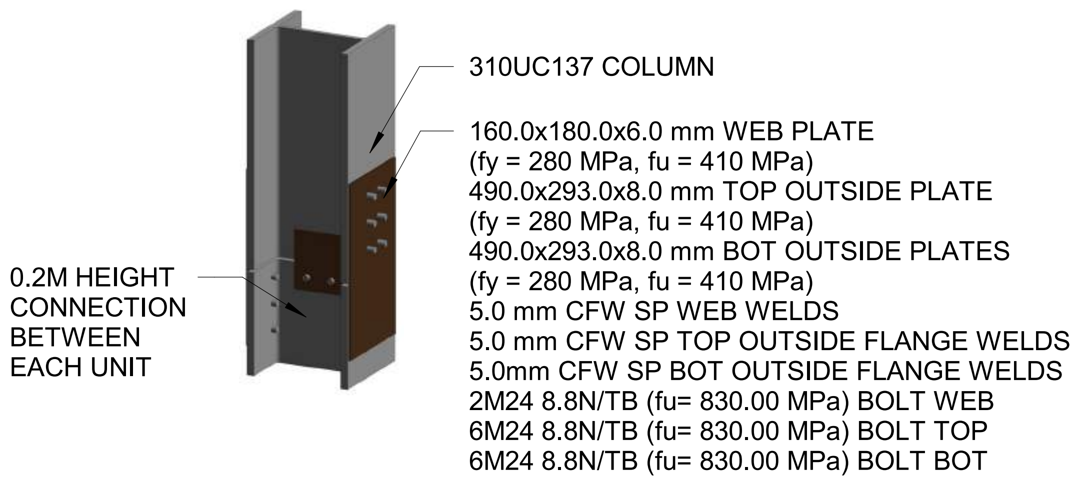
Cross Section of the Whole Structure 1:200



Floor Plan 1:100



Roof Plan 1:100



Detail of key connection/buildup 1:5

STRUCTURAL SYSTEM

Steel frame consisting of steel beam and column. Looking down from the top, the Solar span roof is supported by top beam; for the penultimate floor, the Sipform floor is supported by steel bearer and beam; The steel bearer is required to use to support the Sipform panel; the Sipform wall is supported by beam; the beam is supported by column.

INTERFACES

As shown on the left, these connections are designed to connect each unit and to guarantee the structure's stability. Twelve 310UC137 steel members (Length =0.2m) are connected to the points to make sure they take forces and moments from the above levels. These connections are designed and checked by SPACEGASS

CONSTRUCTION SEQUENCE

1. Engineering Design and Approvals
2. Site development and foundation
3. At the same time of site development, start the plant fabrication of volumetric unit.
3.1 Steel frame - 3.2 Installation of Sipform panel – 3.3 Rough plumping and electrical and clean-up – 3.4 Interior finish like paint – 3.5 Install windows
4. Transportation
5. Assemble operation

MATERIAL CHOICE

• Steel Frame (Steel beam and column) – Resistant to fire, design flexibility, cost effective due to recyclable and durable, easy to install.
• SolarSpan Roof– The maximum span is 6m for 150mm panel. Long-spaning insulated roof panel, high performance with bonding stength.
• Sipform Panel – Prefabricated, reduce construction time and cost, environmentally friendly, high strength racking and shear capacity with used as wall, good insulation rating when using as floor.
• Steel Bearer – The document for Sipform panel requires Steel bearer to support which ensure the span of panel less than 3 meters.

[redacted]

1 Executive Summary

2 Introduction

The modular construction concepts are becoming more and more popular worldwide and they have been extensively implemented by the industries. The main ideas of this concept are time-saving and easy construction of light-weight structures. For modular design concept, most structural components can be prefabricated to the required size and assembled on-site which could save a large amount of time and labours compared to the other buildings use concrete. The skills required for labours could also be reduced as those components could be easily installed.

The following report contains the design for a lightweight four storeys modular houses project located in wind region A, Australia. The details for this project will be elaborated in the following sections, concepts, design criteria, specifications and drawings will also be provided in this document. Assumptions made during the design procedures are provided if it is necessary.

The project scope highlights several constraints that engineers involved in this project have adhere to:

- Design Criteria provided by the client such as dimensions of the modular house
- Australian Design standards such as loading codes and steel design codes

As this project primarily involved the use of a steel frame and different types of structural insulation panels, the selection of members and panels is one of the critical concerns that this structural design must accounted. All decisions made during the design process were analysed in terms of the stability and feasibility of the modular construction and adhere to the clients' requirements at the same time.

The main objective of this report is to delivery client a feasible design of a modular building with high-standard and minimum risk with the completion of scope of works, constraints and design criteria.

3 Design Concept

3.1 Scope of Work (SOW)

Based on the requirement from client and co-operate architect, the following scope of work will be provided in this report:

1. The design concept for the lightweight volumetric modules.
2. Loading criteria and assumption
3. The specifications of the project
4. The vertical and lateral load path calculation and diagram
5. The detailed design for One volumetric module (e.g. Connection)
6. Proposal for the whole four-story structure.
7. Detailed drawings
8. Project outcomes and justifications

The following software will be used to assist with the process of the structure design:

1. SPACEGASS – Analysis of load cases; Selection and testing of member sections; Connection designs.
2. REVIT – The detailed drawing

- The design must consider safety requirements states in the Occupational Safety and Health Law to ensure the volumetric modules are simple and easy to construct.
- The volumetric modules must be lightweight and economical.
- The design must follow and meet the requirements form clients, Australian standards (AS) and National Construction Code (NCC).

3.2 Design Assumption

The following assumptions are considered in this project :

- The volumetric modules are in Wind Region A.
- The superimposed load, i.e. the cladding self-weight is ~1kN/m^2. Wall cladding spans vertically.
- The design of substructure is carried out by another subcontractor based on the reactions provided.
- This report is only the design for superstructure and load checking, the other part such as schedule and cost will be carried out in the following reports (assignment 2)
- **The stairways are excluded from the structure design since it is attached outside the module. The design of stairways would be assumed to be done by other sub-contractors.**
- **Assume this structure is not in the seismic zones, therefore the design for seismic loadings will be excluded from this design report.**

3.3 Structural System

This modular unit structural design is achieved by using a large steel frame formed by beams and columns fulfilled with roof panels, wall panels and floor panels. Refer to section 4 for further details

3.4 Material Choice

The materials of main components of the modular house structure:

3.4.1 Roof panel supplier: Solar span roof panel by BONDOR

- A kind of long-spaning insulated roof panel with high performance with insulation and strength of bonding.

Figure 1 Solar Span roof panel

3.4.2 Wall and floor panel supplier: Sipform

- Sipform Panel – Prefabricated, reduce construction time and cost, environmentally friendly, high strength racking and shear capacity with used as wall, good insulation rating when using as floor. (Ltd n.d.)

Figure 2 Sipform panel

3.4.3 Steel Frame (Columns, Beams and Bearer): Grade 300 310UC137

- Steel Frame (Steel beam and column) – Resistant to fire, design flexibility, cost effective due to recyclable and durable, easy to install. (NWL 2016)

- Steel Bearer – The document for Sipform panel requires Steel bearer to support which ensure the span of panel less than 3 meters.

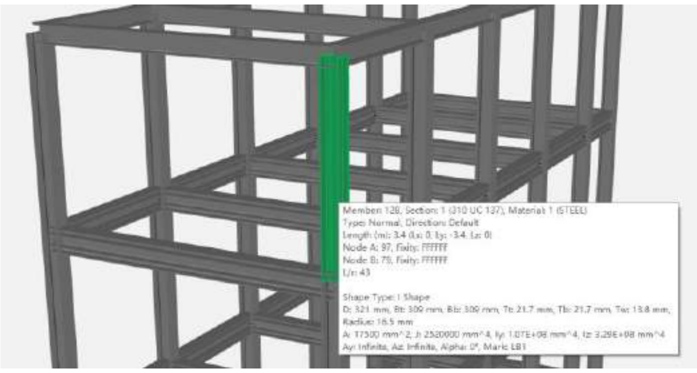


Figure 3 The column section selection form SPACEGASS

3.5 Design Constraints

3.5.1 Wind Action (AS 1170.2 2011)

Results Summary:

The Pressure P: 1.12xCfig=1.12x0.78=**0.87kpa-**ultimate state **P=0.38kpa**- serviceability state

<u>The following wind actions calculations are adhered to Australian Standards 1170.2 2011</u>

- Design dimension**- The single module <14m-length, 54m-width, height-3.5m>**
- Wind region classification**- Region A (Non-cyclonic)**
- **Assume Importance level: 2- Most normal structure- Medium consequence of loss of human life**
- Annual probability of exceedance: **1:500 <BC4 T.B1.2>**
- Regional Wind Speed (Vr)**- From < Table 3.1, AS1170.2>, Region A, and R=500, Vr=45m/s**
- Wind direction multiplier- Md=**1.0- <Clause 3.3>- Assume wind from all directions**
- Overall Height of structure= **4x 3.5m= 14m**
- Terrain category- **TC 2.5- Mz,cat= 0.96, consider Mz,cat=1 <Table 4.1 AS1170.2> for conservative design purpose**
- Shielding parameter: **No specific information provided, assume no shielding, Ms=1.0 for conservative design purpose**
- Topographic parameter: **No specific information provided**, **assume flat surface, Mt=1.0**
- **By using excel spreadsheet (see the Appendix B)- Vsit=43.1 m/s- Ultimate limit state, Vsit=35.1m/s - Serviceability limit state**

- Design wind pressure **(P)= (0.5 P_{air}) [V_{des}]^2 C_{fig}*Cdyn, P_{air}= 1.2kg/m^3 (AS 1720.1 2011)**
- **Design wind load for the topmost point of the structure for conservative purpose**
- From the excel spreadsheet, the **design wind speed is 43.1m/s, the design wind pressure is 0.78 kPa, and the P= 1.12 Cfig (kPa) for the ultimate limit**, **design wind pressure is 0.52(kPa) and P= 0.74 Cfig (kPa) for the serviceability limit**
- From the **table 5.1(A), AS1170.2**, all walls and roof permeable**, Cp,i=-0.2 or 0.0**
- **$C_{fig.i}$= -0.2,0.0 and $C_{fig,e}$= 0.78 kPa**
- **Assume all other factors =1- modular construction and conservative design purpose**
- **THE MAX C_{fig}= 0.78**
- **The Pressure P:** 1.12xCfig=1.12x0.78=**0.87kpa-**ultimate state **P=0.38kpa**-serviceability state

3.5.2 Permanent Load

3.5.2.1 Selection of panels- wall and floor

Results Summary:

Sipform panel thickness=**145mm**

Unit weight= 16.75kg/m^2=16.75*9.81*10^-3= **0.16 kPa**

	R-Value (m^2.K/W)							
	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6	Zone 7	Zone 8
J1.3 Roof and ceiling construction	3.7	3.7	3.7	3.7	3.7	3.2	3.7	4.8
J1.5 Walls and glazing- for Class 2 common area	2.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4
J1.6 Floor- A floor without an in-slab heating or cooling system	2	2	2	2	2	2	2	3.5
Required Panel thickness (mm)	**145**	**145**	**145**	**145**	**145**	**145**	**145**	**215**
Weight kg/m^2	**16.75**	**16.75**	**16.75**	**16.75**	**16.75**	**16.75**	**16.75**	**17.12**

Table 1 R-Value and Required Panel thickness. (Appendix A)

Thermal Insulation Values and Weight with 11mm OSB						
Panel thickness (mm)	**115**	**145**	**165**	**215**	**265**	**315**
R- Values	3.250	4.010	4.517	5.784	7.051	8.317
Weight kg/m²	16.14	16.75	17.12	18.10	19.07	19.56

Table 2 Thermal Insulation Value and Weight of Sipform.

According to Classification Summary of Building and Structures, the modular construction is defined as Class 2 building under National Construction Code (NCC) which means ‘A building consisting of two or more sole-occupancy units and each one is a separate dwelling’. (Building Classifications 2017) The Volume two (ABCB 2019) of NCC including Class 2 of building states that the R-Values requirement for Roof, Wall and Floor for climate zone 1 to 8. (see Appendix A). Due to most regions in Australia are in the climate zone 1 to 7, it is not considered zone 8 in this report. In order to facilitate calculation and reduce cost, the same thickness of Sipform panel will be used for our modular structure in this report. Comparing with all the R-values, it is clear that the Sipform panel shall have R-values larger than 3.7, so the 145mm Sipform panel will be selected which has R-value equals 4.010.

∴ Sipform panel thickness=145mm

Unit weight= 16.75kg/m^2=16.75*9.81*10^-3= **0.16 kPa**

3.5.2.2 Selection of panel: Roof

Results Summary:

Thickness is solar span roof panel **=150mm**

Unit weight = 13kg/m$^{2=}$ (13*9.81)/1000 =0.13kPa – **set to 0.15kPa**

Assume that the roof cladding load≈ 0.1kpa, so, the total rood load is **0.25kPa**

Non-Cyclonic

Panel Properties																			
Panel Thickness (mm)		50			75			100			125			150			200		
'R' Value (m²K/W)		1.60			2.30			2.90			3.60			4.20			5.5		
Wind Class	ULS Design Wind Pressure (kPa)	Max Span (m) Single Span	Max Span (m) Multi-Span	Max. Cantilever (mm)	Max Span (m) Single Span	Max Span (m) Multi-Span	Max. Cantilever (mm)	Max Span (m) Single Span	Max Span (m) Multi-Span	Max. Cantilever (mm)	Max Span (m) Single Span	Max Span (m) Multi-Span	Max. Cantilever (mm)	Max Span (m) Single Span	Max Span (m) Multi-Span	Max. Cantilever (mm)	Max Span (m) Single Span	Max Span (m) Multi-Span	Max. Cantilever (mm)
N2-W33	1.51	3.9	3.6	550	4.5	5.1	900	5.1	6.0	1200	5.7	6.6	1600	6.0	7.2	2400	6.9	8.1	2750
N3-W41	2.35	3.0	2.7	550	3.6	3.9	900	3.9	4.8	1200	4.5	5.1	1600	4.8	5.1	1900	5.5	5.1	2100
N4-W50	3.50	2.1	1.8	550	2.7	2.4	900	3.3	3.3	1200	3.6	3.3	1400	3.9	3.3	1500	4.5	3.3	1500
N5-W60	5.17	1.5	-	550	2.1	1.5	800	2.7	2.1	900	3.0	2.1	900	3.0	2.1	900	3.7	2.1	900

Table 3 Solar Span Panel properties.

Panel Properties						
Panel Thickness (mm)	50	75	100	125	150	200
Typical Mass (kg/m²) based on 0.42/0.6mm skins	11.6	11.9	12.3	12.6	13.0	13.7
SL Grade Total R-value (m²K/W)	1.6	2.3	2.9	3.5	4.2	5.4
M Grade Total R-value (m²K/W)	1.7	2.4	3.1	3.8	4.4	5.8

Note: The above Total R-values are for insulation average temperature of 15˚C. Contact us for other temperatures and different EPS-FR core grades.

Table 4 Solar Span Panel properties - Typical mass

- Panel name: Solar Span, insulation roof
- Check for the span table from <Technical information by Colour bond (Company)>
- Wind region: Non-cyclonic
- Selected by 'maximum span' and 'ULS wind pressure'
- ULS= 0.87kPa [Calculated in Section 'Wind Action'] at the height of the top of the whole structure
- Convert to <AS4055>, wind region is N2
- From the Table 1 above, the required R-value is 3.7. Therefore, from table 2, the 150mm thick solar span panel with R-value equals 4.2 is selected.
- Due to the structure in this report, the single span is used which makes that the maximum span is 6m as stated in the table. The span of our structure is 5.4m which is satisfy the limitation.
- ∴ **Thickness is solar span roof panel =150mm**

  Unit weight = 13kg/m^{2} = (13*9.81)/1000 =0.13kPa - **Say 0.15kPa**

  Assume that the roof cladding load≈ **0.1kpa**

  So, the total rood load is 0.25kPa

3.5.3 Imposed Load

The following decision is made based on Australian Standards AS1170.1

- Type of activity/occupancy for part of the building or structure: **A1** Self-contained dwellings
- Specific uses: Balconies, and roofs used for floor type activities, in self-contained dwellings- **(b) other**
- Uniformly distributed action: **Q=2.0 kPa**

3.6 Vertical and Lateral Load Path

[Calculation in **Appendix C**]

3.6.1 Vertical Load Path (ULS & SLS)

- Permanent Load
  - Solar span panel for Top roof [Supported by beam]
  - Sipform roof and floor panel [Supported by bearer and beam]
  - Sipform wall panel [Supported by beam]
  - Sipform wall panel above opening (Window) [Supported by lintel]
- Imposed Load

3.6.2 Lateral Load Path (ULS & SLS)

- Wind Pressure - End View
- Wind Pressure - Side View

4 Design Detail

4.1 Design Summary:

This four-storey modular unit consists of four separate volumetric units with the height of each unit of 3.3 meters. There are 12 connection points between each floor which are connected with 0.2-meter height steel members. Four volumetric units stock together to give the overall dimensions of this whole building of 14 meters in length, 5.4 meters in width and 13.8 meters in height. All members from this steel frame such as beams, columns, and bearers are 310UC137 steel section. Roof panels, wall panels and floor panels are fulfilled into the steel frame according to certain installation requirements to complete the ultimate design. The following diagram shows the general view of the steel frame with primary structural members. More design details will be shown in the following sub-sections

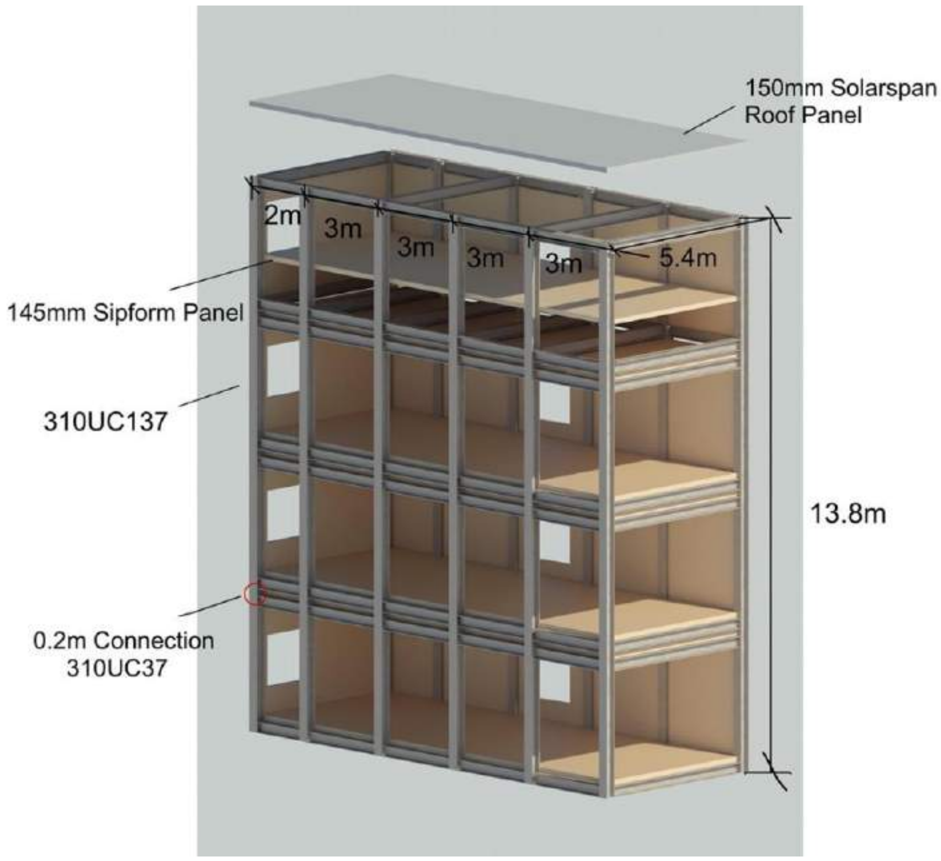


Figure 4 The general over view of the structure

4.2 Design Method

The structural design is based on the floor and elevation plans supplied by the co-operated architect, the following figure is the two-bed room floor plan

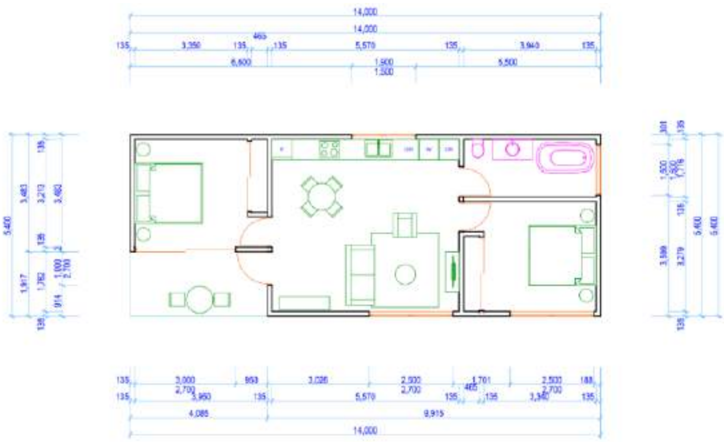


Figure 5 Two bed-room floor plan

To design the primary structural members of this project such as steel beams and columns, the use of "Spacegass" is required. The selection of panels is mainly based on the specifications of panels which supplied by the suppliers such as BONDOR and SIPFORM. The general design procedures are as follow:

- Construct a model based on the floor and elevation plan in Spacegass
- Define wind loads according to the Australian Standards AS1170.2 2011
- Panel selections based on the National Construction Code NCC, Span-table and specifications available from suppliers
- Configure the load path based on the model
- Calculate permeant loads and imposed for structural members
- Define appropriate load combinations based on the Australian Standards AS1170.1 2011
- Enter suitable member fixities for each structural member
- Analyse the model and select proper member size and connections.
- Detail designs for connections between roof panels and walls, wall panels and floor panels.

4.3 Design constraints

The selection of member size of steel frame is subject to the input of the loading conditions such as the primary loads and the different loading combinations. In this section, all the loading cases will be discussed in detail. **One-way load transfer is assumed to be applied in the design.**

4.3.1 Permeant loads

The following figure is the distribution of permeant loads. The dead loads mainly include the self-weight of roof panels, wall panels floor panels and steel members. The specific calculations for permeant load for each structural member could be seen in the appendix C

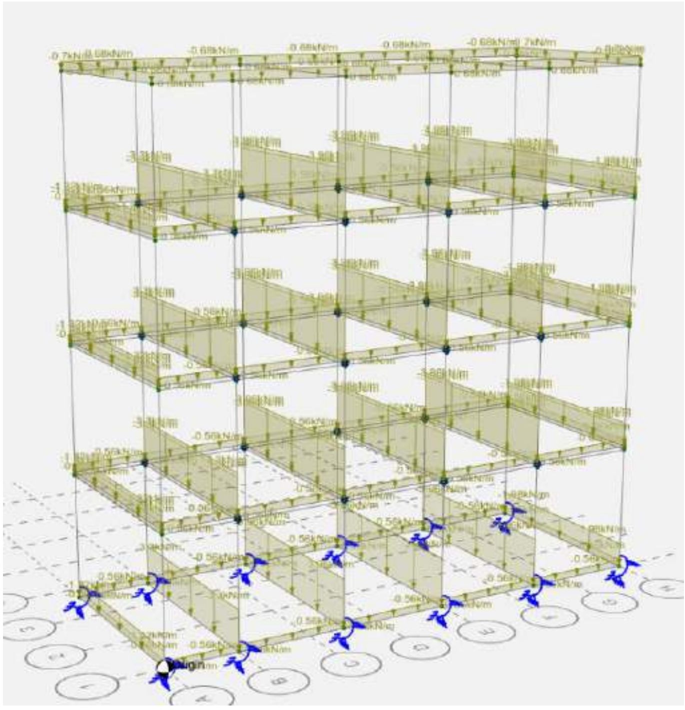


Figure 6 The distribution of dead loads

4.3.2 Live Loads

The attached figure shown the distribution of the live loads, the live loads mainly occurred on bearers since they must support the floor panels with live load on it. Also, the roof top also has imposed loads since it is used for the floor type activities. To see the detailed calculation for live load, refer to the appendix C.

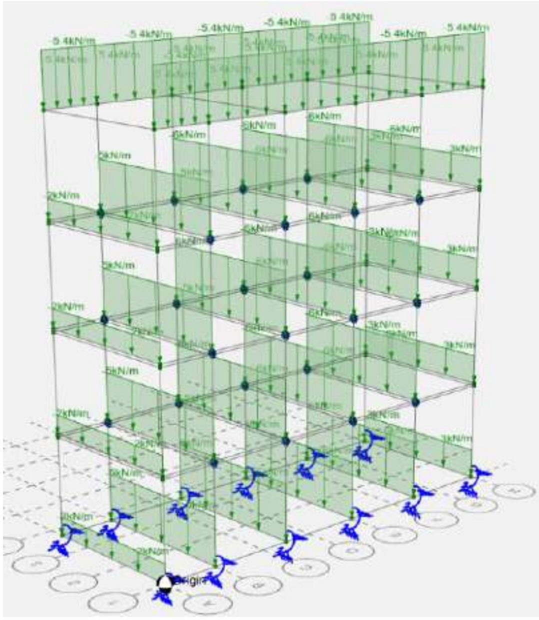


Figure 7 The distribution of live loads

4.3.3 Wind loads

The Permeant and live loads are mainly the loads from the vertical direction. Wind loads are the loads from the lateral direction of the building. There are two lateral load cases in this project, one is to the side wall, the other is to the end wall. The attached figures are those two load cases.

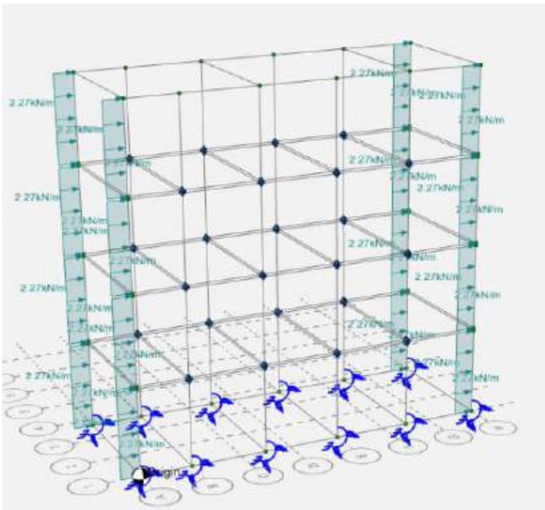


Figure 8 Distribution of lateral load 1

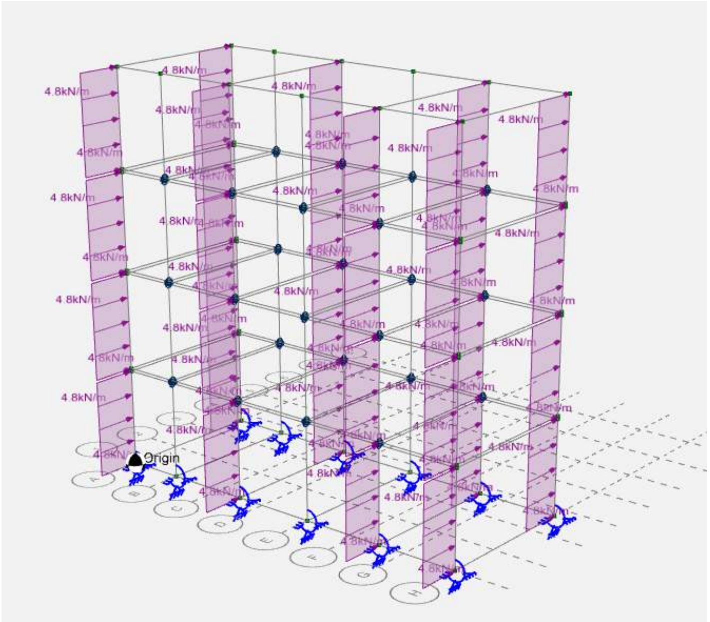


Figure 9 Distribution of lateral load 2

For the detailed lateral load calculations, refer to the appendix C.

Four portal frames are designed in this structure to take the lateral wind loads. The worst-case scenario consideration is applied when inputting loading conditions- all four portal frames need to undertake the largest uniform distributed load-2.27KN/m and 4.8KN/m.

4.3.4 Load Combinations

All chosen combinations are according to the Australian Standards AS1170.0

The following load combinations are chosen for the ultimate strength limit state:

- $1.2G+1.5Q$
- $0.9G+W_u$
- $1.2G+Wu+\psi_c Q$

The load combinations below are chosen for the serviceability limit state:

- $G+\psi_c Q$
- $G+\psi_l Q$
- Wu (Serviceability state)

All these load combinations will be analysed, and the combination gives the worst situations such as largest bending moments, shear forces, deflections would be considered as the critical load combinations. The following figure shows the critical load combination.

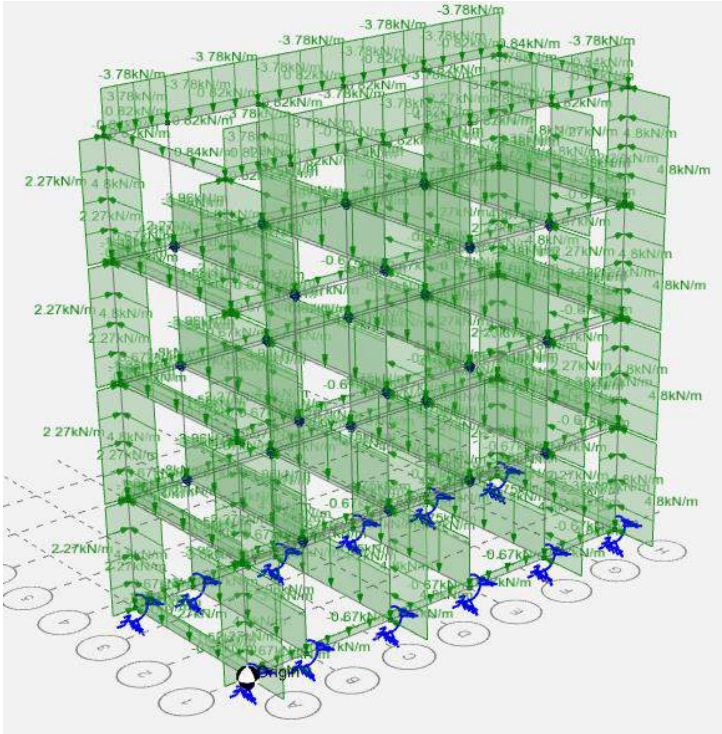


Figure 10 The critical load combination

4.3.5 Member Fixities

Most columns and beams have member fixities FFFFFF, which means they cannot move and rotate in any directions. The connection members between each floor except four points at corners are designed to take forces in all directions and moment from vertical direction with the restraint code FFFRFR. Those four points on corners are designed to take forces and moments from all directions with the restraint code FFFFFF. Those points between the bottom unit and the ground are design to act like pins with the code FFFFRR.

4.4 Results Analysis

Analysis the constructed model by using linear analysis in spacegass for the critical load combination with all member size 310UC137 as shown above, the results are shown as follows:

4.4.1 Deflections

The overview of the deflection of the whole structure:

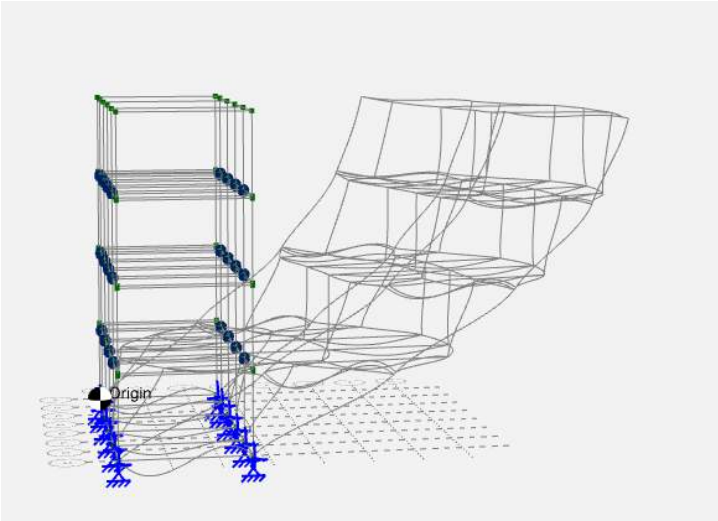


Figure 11 The overview of the structural deflection

With the maximum deflection in X direction 29.3mm

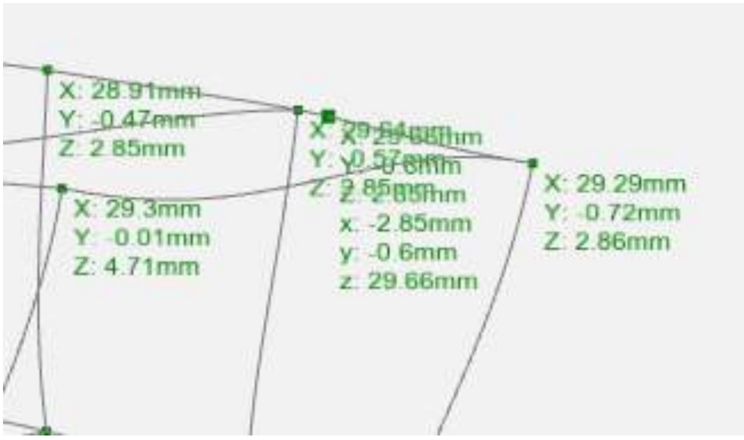


Figure 12 The maximum deflection

4.4.2 Bending moments

The bending moments distribution of the whole structure is shown as:

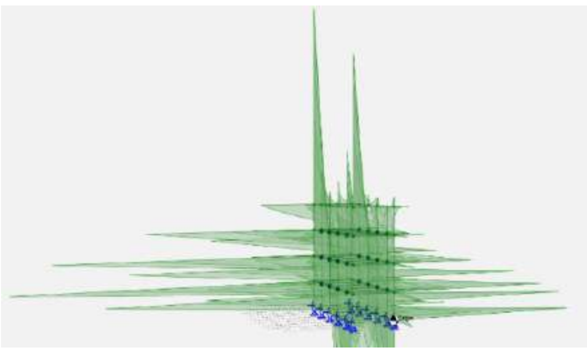


Figure 13 The moment distribution

With the maximum bending moment 147.7KNm

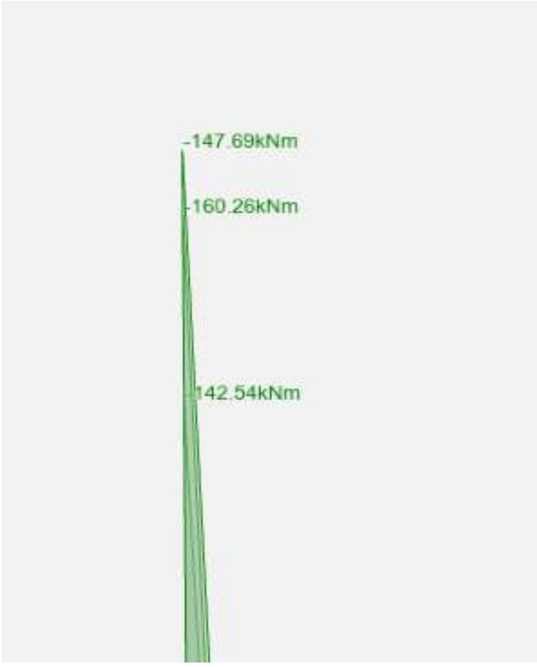


Figure 14 The maximum bending moment

4.4.3 Shear force

The shear force distribution of the structure is shown as follows:

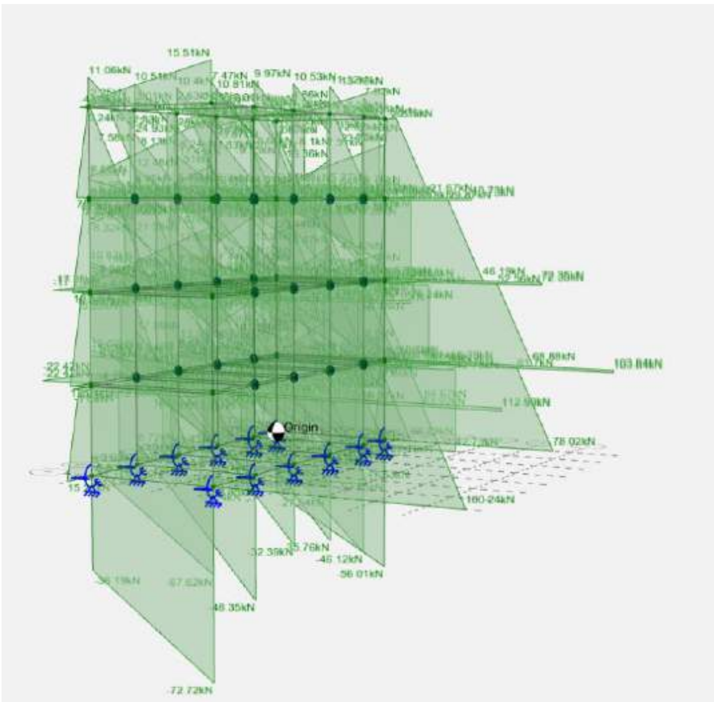


Figure 15 The shear force distribution

With the maximum shear force 113KN

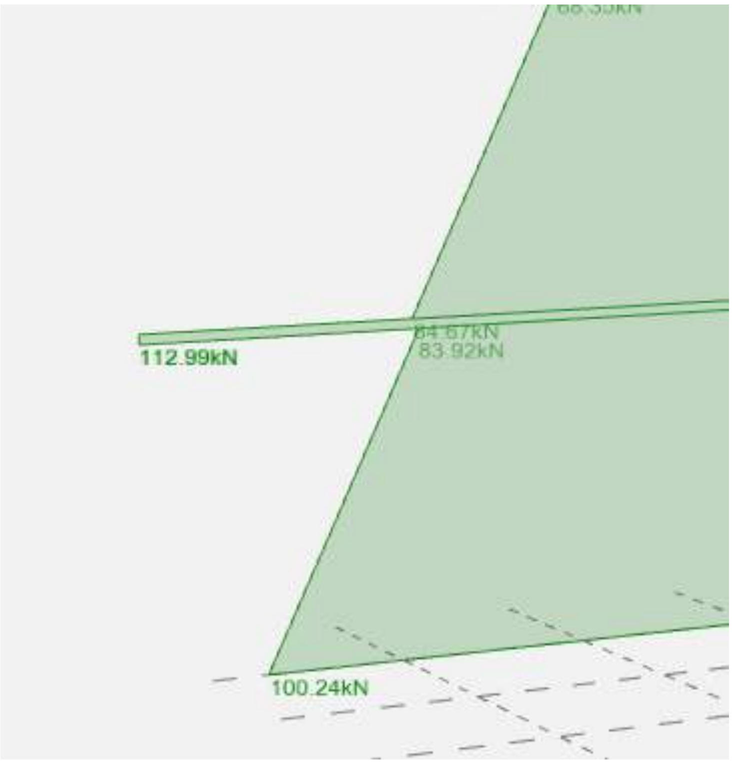


Figure 16 The maximum shear force

4.5 Member Verification

As the results shown above, it could be easily seen that the maximum bending moment and shear force do not govern the member size since they are relatively small compared to the capacities of UC type columns. Instead, the governing factor is the serviceability deflection limit. Based on the Australian Standards AS1170.0 Table C1, the suggest deflection limit for Columns at the top of the building is Height/500, therefore the deflection limit is 28.4mm, the results shown the maximum deflection is 29.3mm, which is accepted. Although, increasing the member size to 310UC158 would reduce the deflection, using 310UC137 would be a more economical solution. Also, since this project is a modular construction-based project, it would be more convenient and timesaving for using the same member size. To do this, by using same member size on the structure would save lots of pre-fabrication time and easy for the transportation. Also, using the same member sizes could be more friendly for on-site installations. Therefore, all structural members such as beams, columns and bearers will be using the same member 310UC137.

4.6 Products and installation requirements

4.6.1 Floor panel

From the SipForm technical appraisal supplied by the SIPFORM company, the general floor panel consists of the following:

- Top skin-10mm Supaboard MgO
- Bottom skin- 6mm Supaboard MgO or 6mm Villaboard
- Inner core- 152mm M grade EPS
- Laminated together based on the pressing specifications
- The maximum span is 3.0 meters

The 150x63 WESBEAM LVL panel jointers and Trufast SIP Screws are used to join the floor panels together

Footings: The design of the footings and supporting structure is dependent on soil classification and loading, but generally may consist of:

- Sure foot SF150 with 4x1200 mm piles
- 65x65x3mm SHS stump (min) at 2.0 meters centres
- 'EZIPIER' top capping system

The following requirements must be achieved when doing the on-site installations:

- Surefoot SF150 installed as per engineer's layout and Surefoot installation instructions
- SHS stumps connected to Sure foot foundation with min 10PL baseplate and 4M16 bolts
- Fix 'EZIPIER' to stump with min 4x 12g-24 TEKS
- Connect bearer to EZIPIER with min 4x12g-24 TEKS
- LVL joiners to be inserted into panel and joined to adjacent panel with SIPFORMS specified polyurethane self-expanding adhesive
- Fix floor panel to LVL jointers with min M10 screws at 300mm c/c
- Connect SIPFLOOR panels to bearers with TRUFAST SIPfasteners SIPLD8000

4.6.2 Wall

According to the technical appraisal, the standard wall panel has the following components:

- Outer Skin- 6mm Fibre Cement or 9.5mm Weather Tex or 10mm Supaboard MgO
- Inner core- 92mm Fire Retardant EPS
- Inner Skin- 6mm Fibre Cement
- Laminated together based on the pressing specifications
- Standard Panel Width 1.2m
- Panel Standard Thickness 104mmx138mm
- Each panel has 3 full length voids for electrical and wiring access

The following requirements must be achieved when doing the on-site installations:

- All panel joins to be sealed prior to painting. Texture Coating
- Rendering or Over-cladding
- Panel Joiners-50x50x1.6 Galv SHS steel columns running full length continuous from top to bottom plate
- Joiners to be inserted into panel and jointed to adjacent panel with SIPFORMS specified polyurethane self-expanding adhesive
- Full-Length 12 m threaded hold down rod tied through bottom plate into slab or floor structure
- Bottom plate-90x45mm or 120x45mm T2 MGP10 Timber
- Top plate-90x45mm or 120x45mm T2 MGP10 Timber

4.7 Connections

Since this project is proposed to build a four-storey modular house, the connections between members and each floor that must be special designed in order to maintain the stability of this structure. The following sections will be displaying the different types of connections. All the designs of these connections are based on the bottom unit under the worst load case. The detailed drawings of some connections will be shown in the executive summary A3 sheet.

4.7.1 Connection between unit

These connections are designed to connect each unit and to guarantee the structure's stability. 12 310UC137 steel members are connected to the points to make sure they take forces and moments from the above levels. These connections are designed and checked by SPACEGASS.

The following figures demonstrate the design of the connections for four corners. Due to the location and arrangement of connection members and columns, the moment carry splice is used.

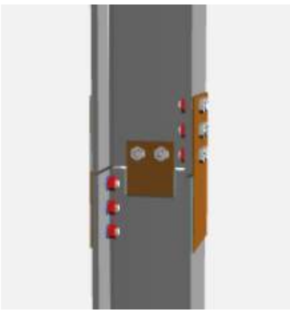


Figure 17 The general view of the connection

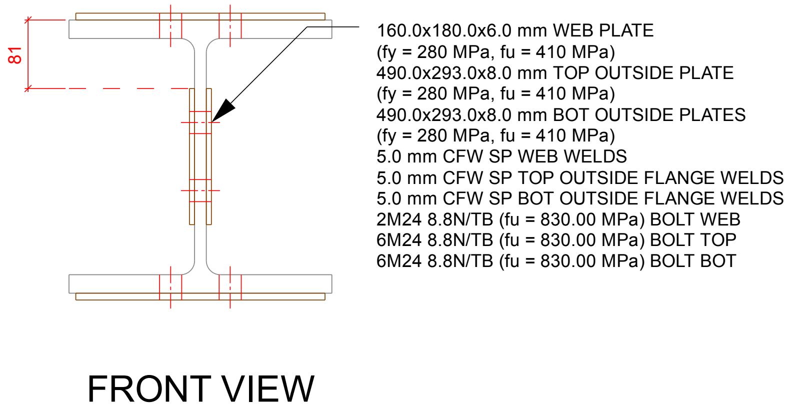


Figure 18 The front view of the connection

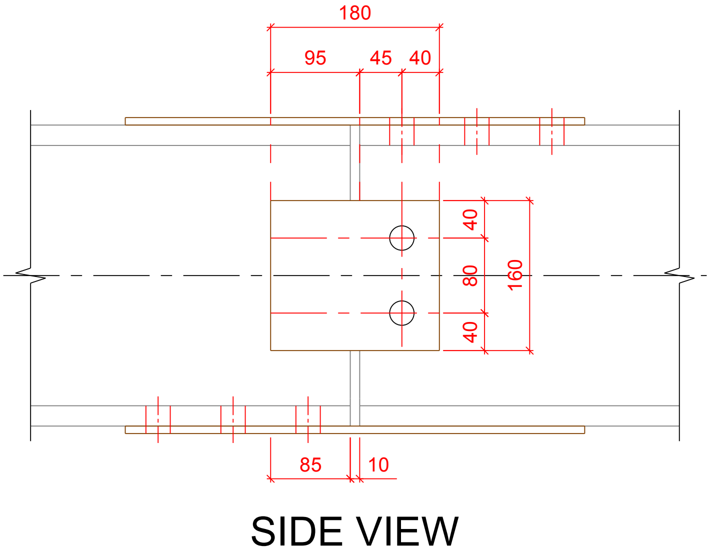


Figure 19 The side view of the connection

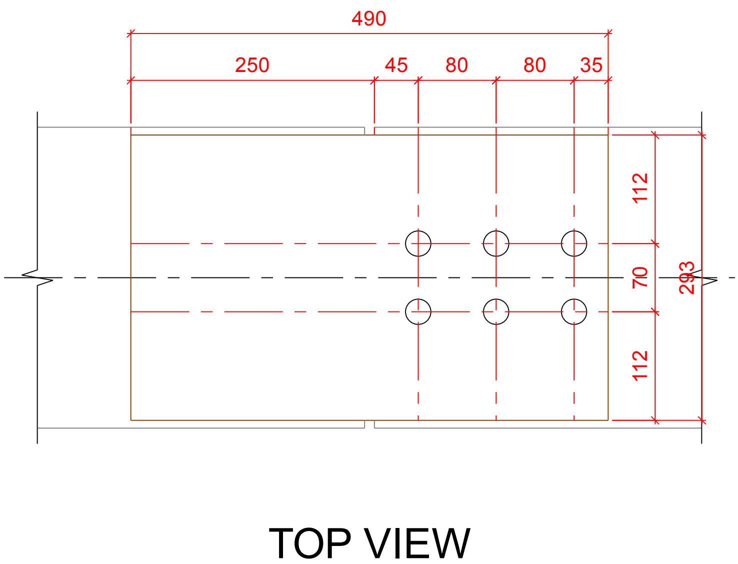


Figure 20 The top view of the connection

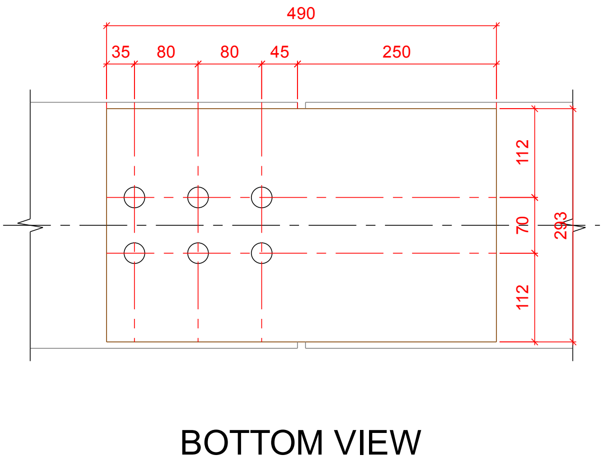


Figure 21 The bottom view of the connection

To see the detailed calculations of this connection, please refer to the appendix D, connection 1

4.7.2 Connection between beam and the web of the column

Most of the beams placed along the side walls of the structure are connected to the web of the columns, therefore the flexible end plate is used to connect these members.

Figure 22 The general view of the connection

To see the detailed calculations for this connection, please refer to the appendix D connection 2

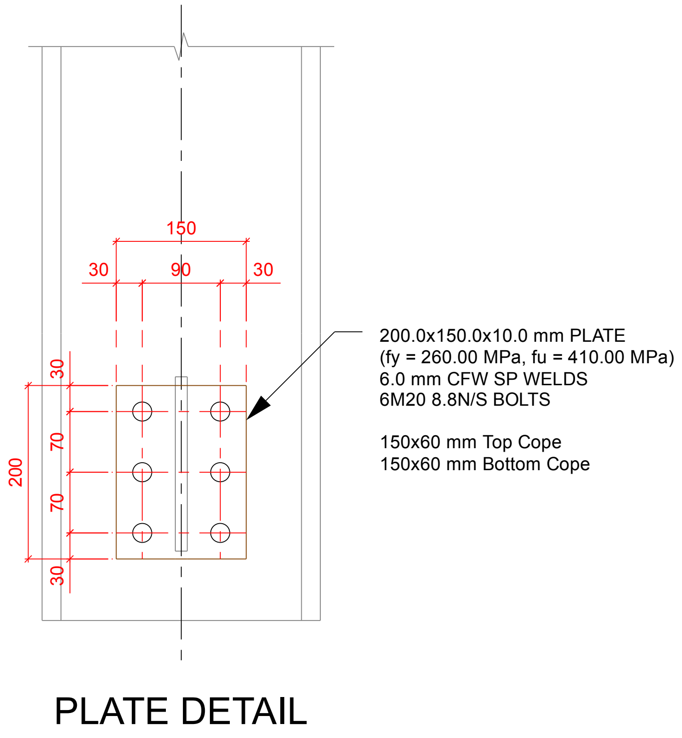


Figure 23 The plate detail of the connection

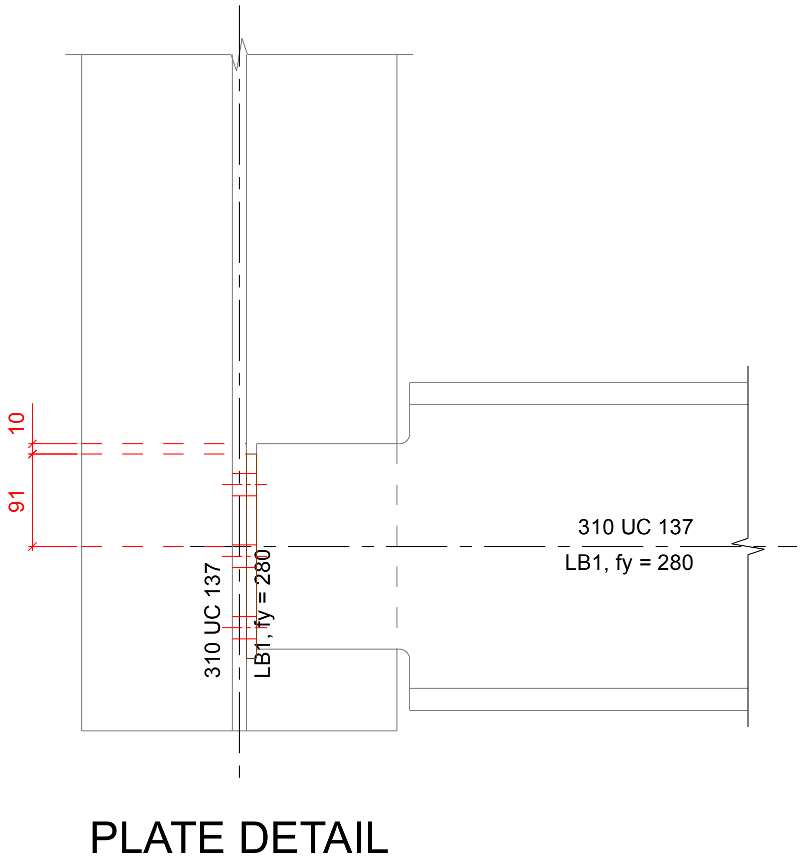


Figure 24 The plate detail of the connection

4.7.3 Connection between beam and the flange of the column

Several beams placed along the end walls of the structure are connected to the flange of the columns, therefore the flexible end plate is used to connect these members.

Figure 25 The general view of the connection

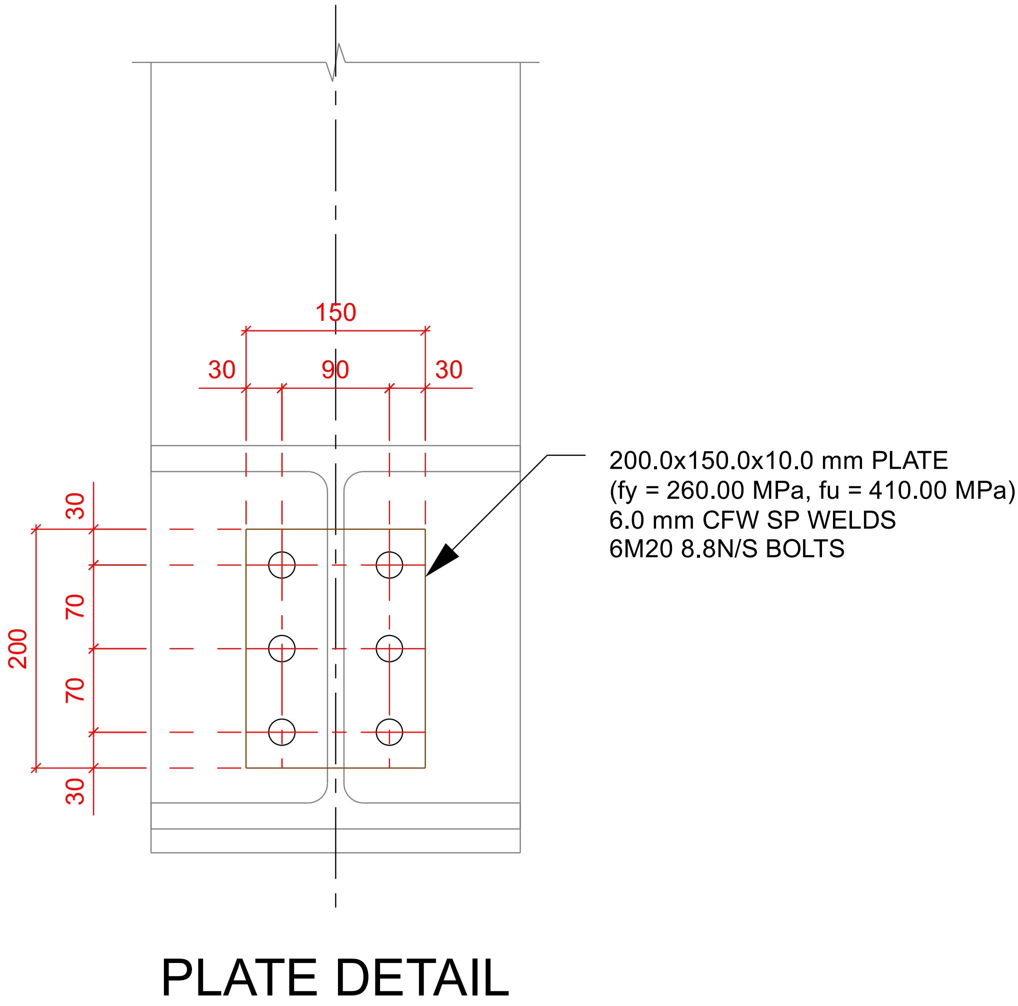


Figure 26 The plate detail of the connection

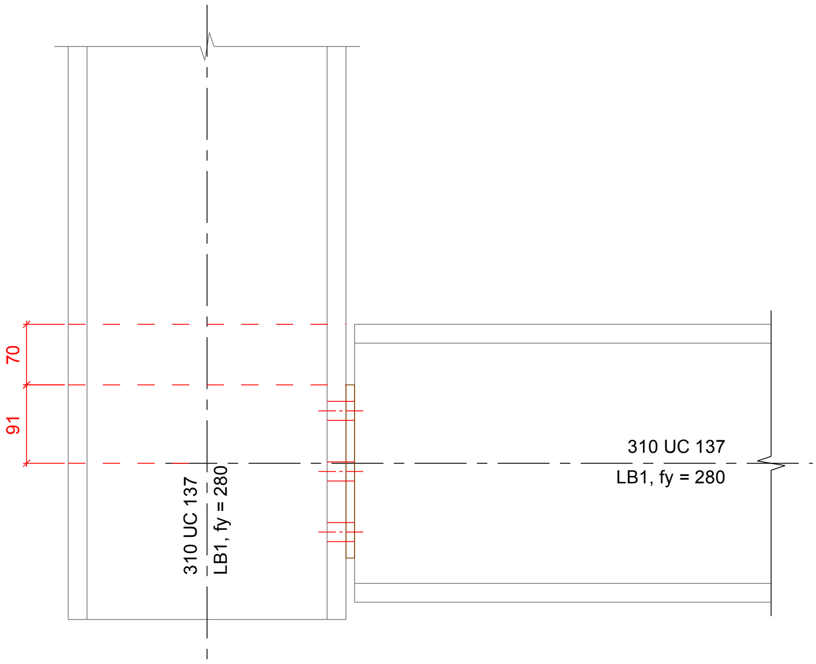


PLATE DETAIL

Figure 27 The plate detail of the connection

To see the detailed calculations for this connection, please refer to the appendix D connection 3

4.7.4 Connection between bearer and beam

The bearers that support the floor panels also need to be connected to the beams along the side walls of the structure. The following figures show the design details.

Figure 28 The general view of the connection

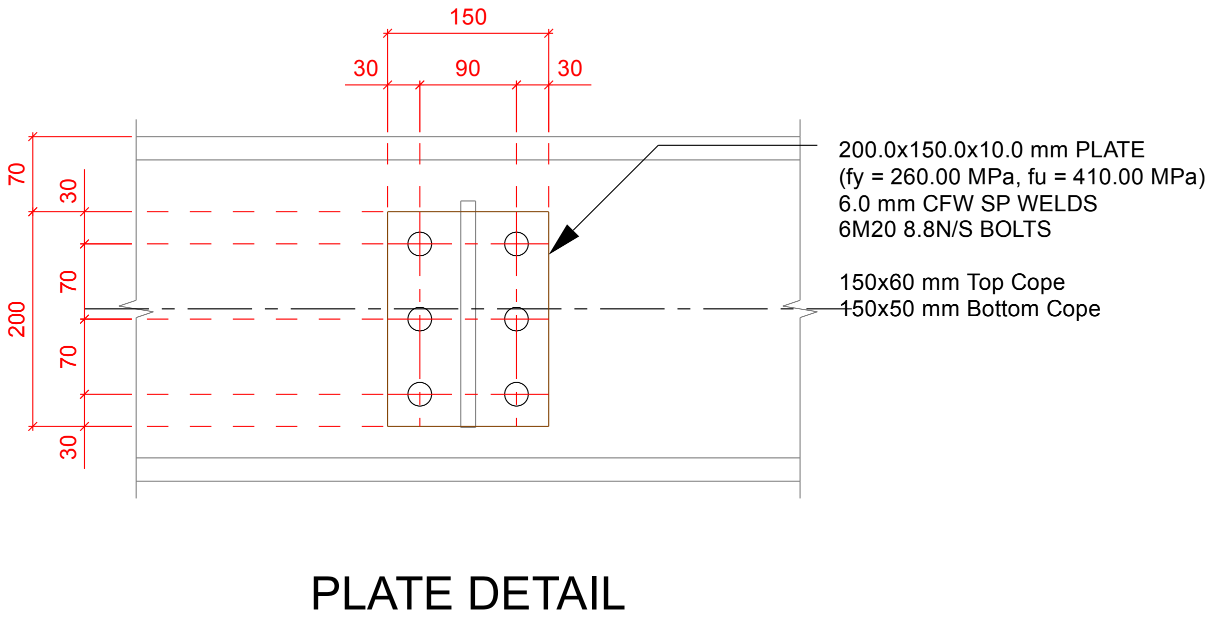


Figure 29 The plate detail of the connection

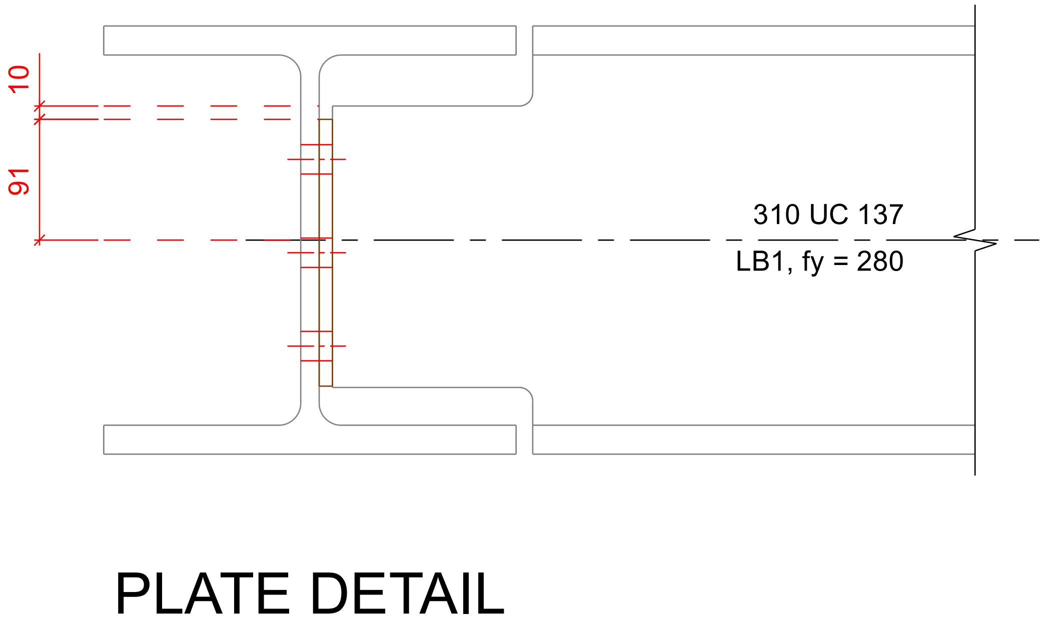


Figure 30 The plate detail of the connection

To see the detailed calculations for this connection, please refer to the appendix D connection 4

5 Teamwork& Self-Management

5.1 Meeting Minutes

Sem-week	Date of meeting	Task
1	24/02	• Formation of Group of 3 - Group 10
	26/02	• Meeting with Architect • Create Facebook group chat
2	07/03	• Architect finishes the design and selects certain materials for panel and claddings • Check the drawings sent by architect and search the information of the Sipform panel
3	11/03	• Meeting with Architect - Discussion of stairs and some other details about the drawing - Arrange next meeting
4	18/03	• Scope of Work • Discussion of materials to use - steel beam and column, Sipform panel for wall, roof and floor
5	25/03	Additional Non-contact week Due to COVID-19, the face-to-face meeting change to online meeting
6	01/04	• Selection of thickness of Sipform panel using R-value • Calculation of wind action • Imposed load and panel dead load • Written of report
7	08/04	• Discussion of structure system - The location of each member
8	15/04	• Discussion of load path - Calculation of vertical load - preliminary stage -selection of member
9	22/04	• Modelling using SPACEGASS - Only the basic structure of one volumetric unit • Format the structure of report
	23/04	• Detail discussion: location of bottom beam, top plate between Sipform and steel member • Add vertical and lateral load to structure using SPACEGASS • Discussion of Connection
	25/04	• Discussion of Connection • Check load case using SPACEGASS
10	29/04	• Written of report
11	05/05	• Finalise the report and calculation

6 Bibliography

ABCB. 2019. “Volume Two.” *National Construction Code.*

2011. *AS 1170.2.* Standards Australia .

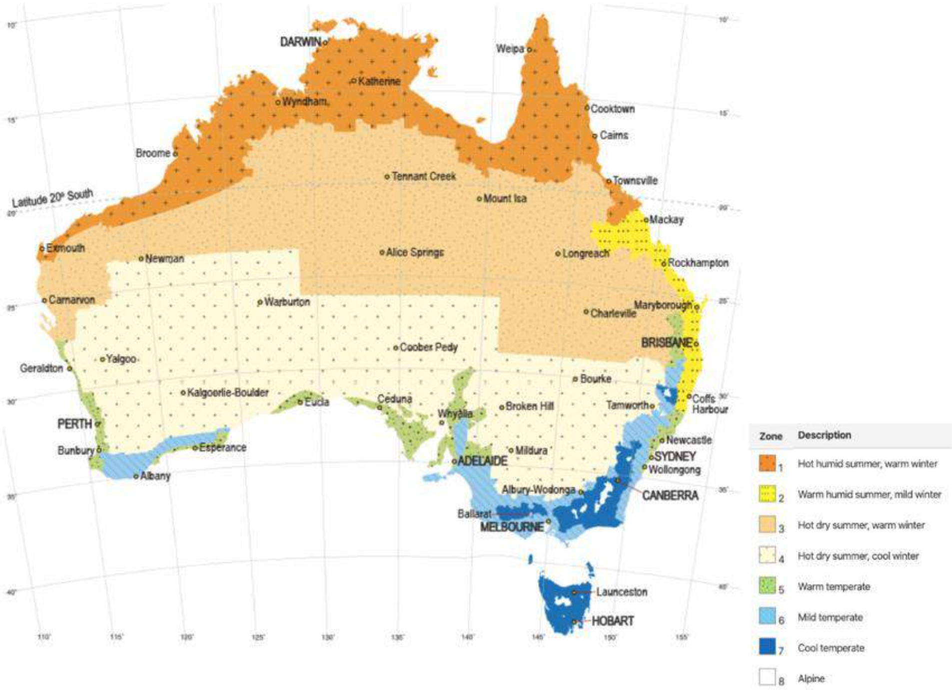
2017. “Building Classifications.” *ABCB.* www.abcd.dov.au.

Ltd, Structural Panels Australia Pty. n.d. “Technical Data & Engineering Manual.” *Structural Panels.* https://structuralpanels.com.au/wp-content/uploads/2015/10/SIPS.pdf?fbclid=IwAR2d6zJSOaho8AOef0E7VrYmpmF0DWc4ww0B-bDAkhQ1nbDWGWzmy_gLVME.

NWL. 2016. *NWL.* 5 11. http://northern-weldarc.com/advantages-steel-framing/.

7 Appendices

Appendix A



J1.3 Roof and ceiling construction

(a) A roof or ceiling must achieve a *Total R-Value* greater than or equal to—

(i) in *climate zones* 1, 2, 3, 4 and 5, R3.7 for a downward direction of heat flow; and

(ii) in *climate zone* 6, R3.2 for a downward direction of heat flow; and

(iii) in *climate zone* 7, R3.7 for an upward direction of heat flow; and

(iv) in *climate zone* 8, R4.8 for an upward direction of heat flow.

(b) In *climate zones* 1, 2, 3, 4, 5, 6 and 7, the solar absorptance of the upper surface of a roof must be not more than 0.45.

SA J1.3(c)

(d) Wall components of a *wall-glazing construction* must achieve a minimum *Total R-Value* of—

(i) where the wall is less than 80% of the area of the *wall-glazing construction*, R1.0; or

(ii) where the wall is 80% or more of the area of the *wall-glazing construction*, the value specified in Table J1.5a.

Table J1.5a Minimum wall Total R-Value - Wall area 80% or more of wall-glazing construction area

Climate zone	**Class 2 common area, Class 5, 6, 7, 8 or 9b building or a Class 9a building other than a *ward area***	**Class 3 or 9c building or Class 9a *ward area***
1	2.4	3.3
2	1.4	1.4
3	1.4	3.3
4	1.4	2.8
5	1.4	1.4
6	1.4	2.8
7	1.4	2.8
8	1.4	3.8

J1.6 Floors

(a) A floor must achieve the *Total R-Value* specified in Table J1.6.

(b) A floor must be insulated around the vertical edge of its perimeter with insulation having an *R-Value* greater than or equal to 1.0 when the floor—

(i) is a concrete slab-on-ground in *climate zone* 8; or

(ii) has an in-slab or in-screed heating or cooling system, except where used solely in a bathroom, amenity area or the like.

(c) Insulation *required* by (b) for a concrete slab-on-ground must—

(i) be water resistant; and

(ii) be continuous from the adjacent finished ground level—

(A) to a depth not less than 300 mm; or

(B) for the full depth of the vertical edge of the concrete slab-on-ground.

Table J1.6 Floors - Minimum Total R-Value

Location	***Climate zone* 1 — upwards heat flow**	***Climate zones* 2 and 3 — upwards and downwards heat flow**	***Climate zones* 4, 5, 6 and 7 — downwards heat flow**	***Climate zone* 8 — downwards heat flow**
A floor without an in-slab heating or cooling system	2.0	2.0	2.0	3.5
A floor with an in-slab heating or cooling system	3.25	3.25	3.25	4.75

Appendix B

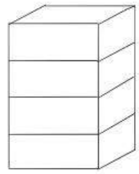
BUILDING IMPORTANCE/LOCATION DATA

Importance Level	=	2
Region	=	A
Terrain Category	=	2.5

DETERMINE BASIC WIND PRESSURE

Limit State		Ultimate	Serviceability		
Return Period	R =	500	20	yrs	[BCA,AS1170.2]
Additional ultimate factor for region C / D	F =	1.00	1.00		
Regional 3s Wind Gust	V_R =	45.0	37	m/s	
Wind directional multiplier	M_d =	1			
Building Height	h =	14	m		
Terrain/Height Multiplier	$M_{z,cat}$ =	0.96	0.96		
Sheilding multiplier	M_s =	1			
Topographic multiplier	M_t =	1			
Design Wind Speed (all directions)	$V_{des,all}$ =	43.1	35.1	m/s	
Design Wind Pressure (all directions)	p =	1.12	0.74	.Cfig kPa	
Ultimate/Serviceability	=	1.51			

Appendix C



↳ Sipform Panel (support by Bearer and Beam)

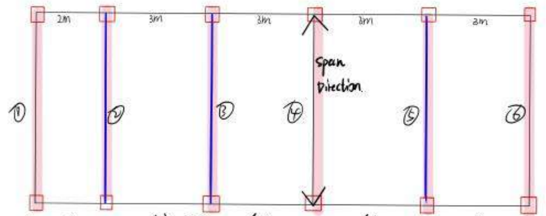
- Sipform ($t = 145$ mm, 16.75 kg/m²) – Sipform

  $16.75 \frac{kg}{m^2} \times \frac{9.81}{1000} = 0.16 \frac{kN}{m^2}$ (kPa) (per m²)

- Due to NCC, the slab thickness has to be larger than 200mm, Therefore. 2-145mm Sipform Panel will be joined together at the connection between 2nd, 3rd and 4th Floors.

- Assume the superimposed load = 1.0 kPa. (roof and wall cladding self-weight).

- ∴ Total G = (2×0.16 kPa) + 1kPa = 1 a.



※ Because it is only a one-way load transfer. only Beam ①~⑥ take load transfer.

1m, 2.5m, 3m, 3m, 3m, 1.5m

W = 1.32 kPa × 1m = 1.32 kN/m.

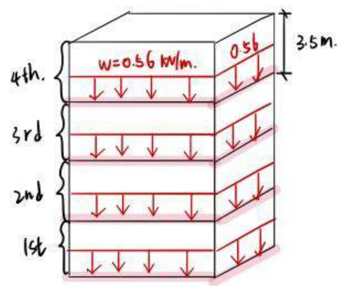
W = 1.32 kPa × 2.5m = 3.3 kN/m.

W = 1.32 kPa × 3m = 3.96 kN/m

W = 1.32 kPa × 1.5m = 1.98 kN/m.

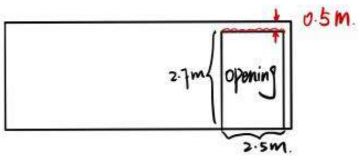
↳ Wall Panel. (supported by Beam).

- W = 0.16 kPa × 3.5m = 0.56 kN/m.



↳ Wall Panel (Supported by lintel).

- W = 0.16 kPa × 0.5 m = 0.08 kN/m.

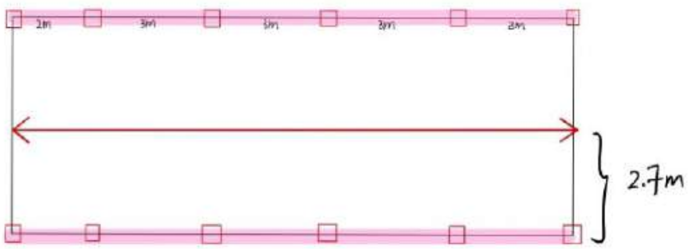


② Apply imposed Load

From <AS 1170.1 , Table 3.1>

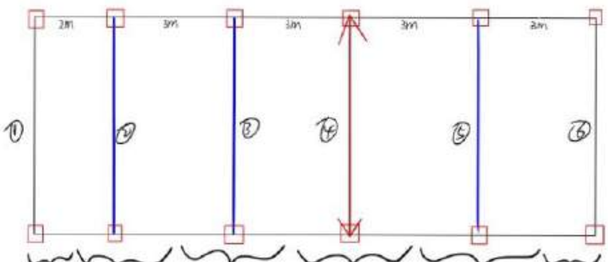
A2 → General area , bedrooms → Uniform Distributed Action = 2.0 kPa.

↳ Longer Beam (only for solar span roof).



W = 2.0 Pa × 2.7 m = 5.4 kN/m.

↳ shorter Beam. (for Sipform panel).



1m → W = 2kPa × 1m = 2 kN/m

2.5m → W = 2×2.5 = 5 kN/m

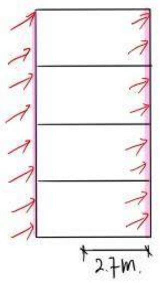
3m, 3m, 3m → W = 2× 3 = 6 kN/m

1.5m → W = 2 × 1.5 = 3 kN/m

Lateral Load

* Wind Pressure for the whole structure is
  P = 0.87 KPa – Ultimate State
  P = 0.38 KPa – Serviceability State.

↳ End View.



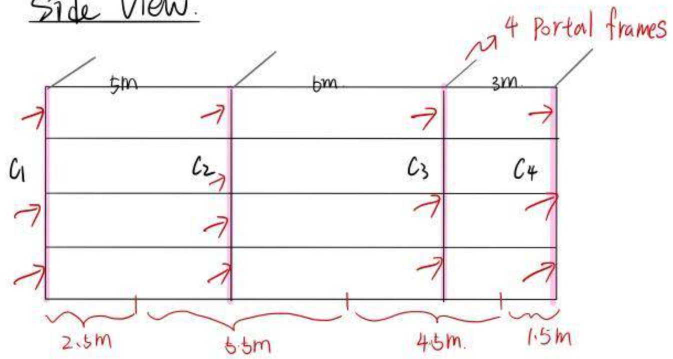
• Ultimate state.

W = 0.87 kPa × 2.7 m = **2.27 kN/m.**

• Serviceability state

W = 0.38 kPa × 2.7m = **1.0 kN/m.**

↳ Side View.



• Ultimate state.

C1 : W = 0.87 kPa × 2.5m = **2.2 kN/m**

C2 : W = 0.87 kPa × 5.5m = **4.8 kN/m**

C3 ; W = 0.87 kPa × 4.5m = **3.9 kN/m.**

C4 ; W = 0.87 kPa × 1.5m = **1.3 kN/m.**

• Serviceability state.

C1 : W = 0.38 kPa × 2.5m = **0.95 kN/m**

C2 : W = 0.38 kPa × 5.5m = **2.1 kN/m**

C3 ; W = 0.38 kPa × 4.5m = **1.71 kN/m.**

C4 ; W = 0.38 kPa × 1.5m = **0.6 kN/m.**

* Use the worst case. 4.8kN/m.

Appendix D

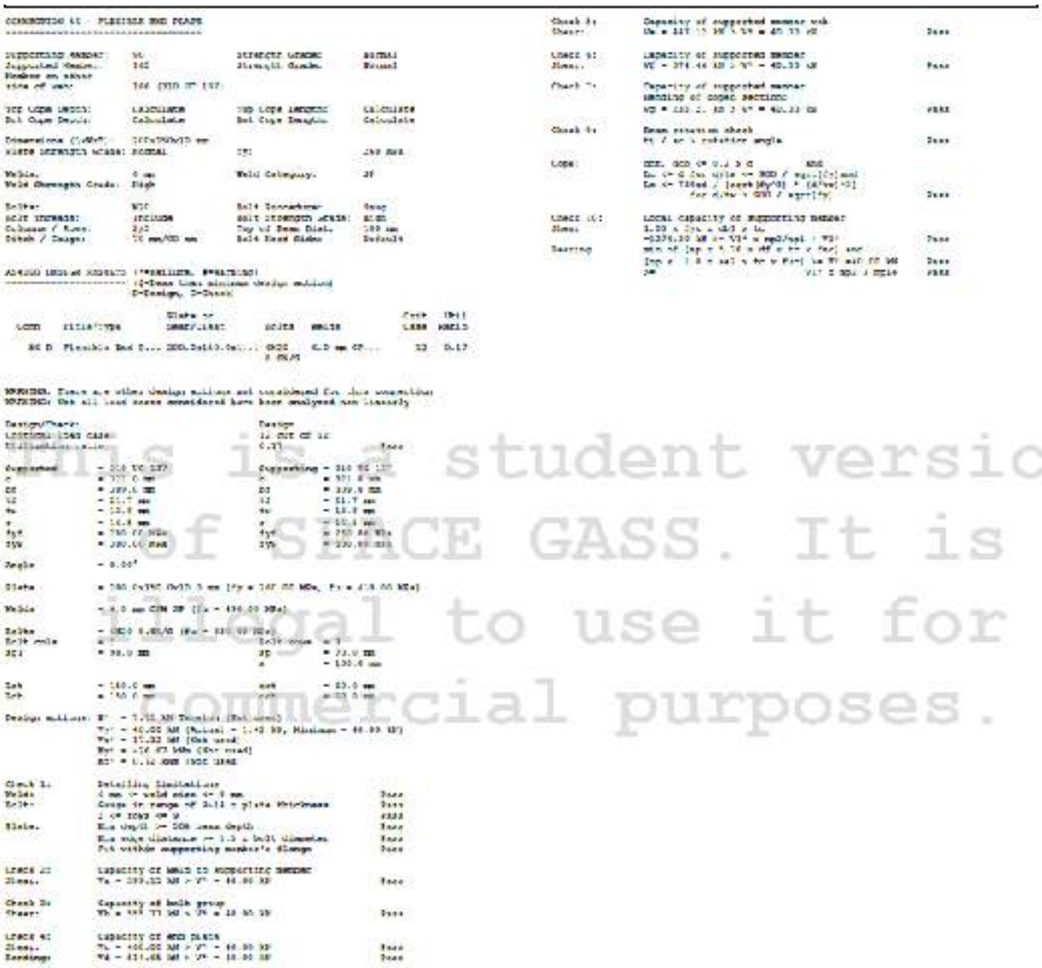
The detailed calculation for connection 1

```
CONNECTION 78 - BOLTED / WELDED SPLICE
--------------------------------------

Supported Member 1:   119              Strength Grade:       Normal
Supported Member 2:   91               Strength Grade:       Normal

Clearance:            10 mm

Web Plate:
Dimensions (LxWxT):   160x180x6 mm
Plate Strength Grade: Normal           fy:                   280 MPa

Welds:                5 mm             Weld Category:        SP
Weld Strength Grade:  High

Bolts:                M24              Bolt Procedure:       Bearing
Bolt Threads:         Include          Bolt Strength Grade:  High
Columns / Rows:       1/2              Edge Dist:            45 mm
Pitch:                80 mm            Gauge:                80 mm
Bolt Head Side:       Default

Top Outside Flange Plate:
Dimensions (LxWxT):   490x293x8 mm
Plate Strength Grade: Normal           fy:                   280 MPa

Welds:                5 mm             Weld Category:        SP
Weld Strength Grade:  High

Bolts:                M24              Bolt Procedure:       Bearing
Bolt Threads:         Include          Bolt Strength Grade:  High
Columns / Rows:       2/3              Edge Dist:            45 mm
Pitch:                80 mm            Gauge:                0 mm
Bolt Head Side:       Default          Web Gauge:            70 mm

Bottom Outside Flange Plate:
Dimensions (LxWxT):   490x293x8 mm
Plate Strength Grade: Normal           fy:                   280 MPa

Welds:                5 mm             Weld Category:        SP
Weld Strength Grade:  High

Bolts:                M24              Bolt Procedure:       Bearing
Bolt Threads:         Include          Bolt Strength Grade:  High
Columns / Rows:       2/3              Edge Dist:            45 mm
Pitch:                80 mm            Gauge:                0 mm
Bolt Head Side:       Default          Web Gauge:            70 mm

AS4100 DESIGN RESULTS (F=Failure, W=Warning)
--------------------- (?=Less than minimum design action)
                      (D=Design, C=Check)

                          Plate or                                    Crit   Util
Conn   Title/Type         Seat/Cleat             Bolts    Welds       Case   Ratio

 78 D  Bolted / Weldc...  Top Outside F...       6M24     5.0 mm CF...  12    0.98
                          490.0x293.0x8...       8.8N/TB
                          Bot Outside F...       6M24     5.0 mm CF...
                          490.0x293.0x8...       8.8N/TB
                          Web Plate              2M24     5.0 mm CF...
                          160.0x180.0x6...       8.8N/TB

WARNING: There are other design actions not considered for this connection
WARNING: Not all load cases considered have been analysed non-linearly

Design/Check:                          Design
Critical load case:                    12 out of 12
Utilization ratio:                     0.98                 Pass

Supported          = 310 UC 137
d                  = 321.0 mm
bf                 = 309.0 mm
tf                 = 21.7 mm
tw                 = 13.8 mm
r                  = 16.5 mm
fyf                = 280.00 MPa
fyw                = 300.00 MPa

Web plate          = 160.0x180.0x6.0 mm (fy = 280.00 MPa, fu = 410.00 MPa)

Top outside plate  = 490.0x293.0x8.0 mm (fy = 280.00 MPa, fu = 410.00 MPa)

Bot outside plate  = 490.0x293.0x8.0 mm (fy = 280.00 MPa, fu = 410.00 MPa)

Bolts @ Web        = 2M24 8.8N/TB (fu = 830.00 MPa)
Cols.              = 1                     Rows         = 2
sg1                = 80.0 mm               sp           = 80.0 mm
ae@TopPlate        = 45.0 mm               ae@BotPlate  = 45.0 mm
ae@WebPlate        = 45.0 mm

Bolts @ Top        = 6M24 8.8N/TB (fu = 830.00 MPa)
Cols.              = 2                     Rows         = 3
sg1                = 0.0 mm                sg2          = 70.0 mm
sp1                = 80.0 mm               sp2          = 90.0 mm

Bolts @ Bot        = 6M24 8.8N/TB (fu = 830.00 MPa)
Cols.              = 2                     Rows         = 3
sg1                = 0.0 mm                sg2          = 70.0 mm
sp1                = 80.0 mm               sp2          = 90.0 mm

Web welds           = 5.0 mm CFW SP (fu = 490.00 MPa)

Top outside welds  = 5.0 mm CFW SP (fu = 490.00 MPa)

Bot outside welds  = 5.0 mm CFW SP (fu = 490.00 MPa)

Design actions: N*  = 49.27 kN Compression
                Vy* = 107.64 kN (Actual = 45.55 kN, Minimum = 107.64 kN)
                Vz* = 4.07 kN (Not Used)
                My* = 1.06 kNm (Not Used)
                Mz* = 166.04 kNm (Actual = 19.72 kNm, Minimum = 166.04 kNm)

Check 1:        Capacity of bolts at flanges
Flange:         ϕVfb = 708.40 kN > Nft* = 529.05 kN                Pass
                ϕVfb = 708.40 kN > Nfc* = 580.45 kN                Pass

Check 2:        Capacity of welds at welded flange
Ten. Flange:    ϕVwf = 642.79 kN > Nft* = 529.05 kN                Pass
Comp.Flange:    ϕVwf = 642.79 kN > Nfc* = 580.45 kN                Pass

Check 3:        Capacity of flange cover plates
Ten. Flange:    ϕNpt = 590.69 kN > Nft* = 529.05 kN                Pass
Comp.Flange:    ϕNpc = 590.69 kN > Nfc* = 580.45 kN                Pass

Check 4:        Capacity of bolts in web cover plate
                Design requirements:
                ϕMin = 21.34 kNm > Mw* = 4.84 kNm                  Pass
                ϕVin = 333.54 kN > Nw* = 16.98 kN                  Pass
                ϕVir = 333.54 kN > Vw* = 107.64 kN                 Pass
                A = (Mw/ϕMin Nw/ϕVin)^2 = 0.28
                B = (-Vw/ϕVdv)^2 = -0.2
                A + B = 0.11 < 1                                   Pass

                Additional requirements:
                0.9 (aey x tf x fuf) > Vwb*                         Pass
                0.9 (ae2 x tw x fuw)/2 > Vwb*                       Pass
                0.9 (ae3 x tf x fuf) > -Vwb* + Vwb*                 Pass
                0.9 (ae4 x tf x fuf) > Vwb* - Vwb*                  Pass
                0.9 (ae4 x tw x fuw)/2 > Vwb* - Vwb*                Pass
```



```
Check 5:          Capacity of welds around web cover plates
Parameters:
                  Fx* = -7.49 kN
                  Fy* = 53.82 kN
                  Mz* = 2.42 kNm
                  Iwp = 1600066 mm^3
                  Lwx = 330.0 mm
                  Lwy = 330.0 mm
                  vx*             = 0.090 kN/mm
                  vy* (left)      = -0.132 kN/mm
                  vy* (right)     = -0.254 kN/mm

Shear:            ϕVw = 0.532 kN/mm > Vres* = 0.269 kN/mm              Pass

Check 6:          Capacity of web cover plates
Shear:            ϕVwd = 241.92 kN > Vw* = 107.64 kN                   Pass
Axial:            ϕNwd = 477.04 kN > Nw* = 16.90 kN                    Pass
Bending:          ϕMwd = 18.85 kNm > Mw* = 3.81 kNm                    Pass
Bending and axial force:
                  ϕMwr = 15.07 kNm > Mw* = 4.04 kNm                    Pass

Check 7:          Capacity of flanges of spliced member
Tens.:            ϕNft = 1639.74 kN > Nft* = 529.05 kN                 Pass
Comp:             ϕNfc = 1639.74 kN > Nfc* = 580.45 kN                 Pass

Check 8:          Capacity of spliced member at splice location
                  ϕMrs = 488.72 kNm > M* = 166.04 kNm                  Pass
```

The detailed calculations for connection 2



The detailed calculations for connection 3

```
CONNECTION 35 - FLEXIBLE END PLATE
----------------------------------

Supporting Member:    41              Strength Grade:       Normal
Supported Member:     73              Strength Grade:       Normal

Top Cope Depth:       Calculate       Top Cope Length:      Calculate
Bot Cope Depth:       Calculate       Bot Cope Length:      Calculate

Dimensions (LxWxT):   230x150x10 mm
Plate Strength Grade: Normal          fys                   260 MPa

Welds:                6 mm            Weld Category:        SP
Weld Strength Grade:  High

Bolts:                M20             Bolt Procedure:       Snug
Bolt Threads:         Include         Bolt Strength Grade:  High
Columns / Rows:       2/3             Top of Beam Dist:     100 mm
Pitch / Gauge:        70 mm/90 mm     Bolt Head Side:       Default

AS4100 DESIGN RESULTS (*=Failure, #=Warning)
--------------------- ()=Less than minimum design action)
                      (D=Design, C=Check)

                              Plate or                                   Crit  Util
  Conn    Title/Type          Seat/Cleat        Bolts    Welds           Case  Ratio

    35 D  Flexible End P... 230.0x150.0x1... 6M20    6.0 mm CF...        12   0.15
                                              x 8.8/S

WARNING: There are other design actions not considered for this connection
WARNING: Not all load cases considered have been analysed non-linearly

Design/Check:                                  Design
Critical load case:                            12 out of 12
Utilization ratio:                             0.15               Pass

Supported       = 310 UC 137                   Supporting = 310 UC 137
d               = [illegible] mm               d          = [illegible] mm
bf              = 309.0 mm                     bf         = 309.0 mm
tf              = 21.7 mm                      tf         = 21.7 mm
tw              = 13.8 mm                      tw         = 13.8 mm
r               = 16.5 mm                      r          = 16.5 mm
fyf             = [illegible] MPa              fyf        = [illegible] MPa
fyw             = [illegible] MPa              fyw        = [illegible] MPa

Angle           = 0.00°

Plate           = 230.0x150.0x10.0 mm (fy = 260.00 MPa, fu = 410.00 MPa)

Welds           = 6.0 mm CFW SP (fu = 490.00 MPa)

Bolts           = 6M20 8.8N/S (fu = 830.00 MPa)
Bolt cols       = 2                            Bolt rows  = 3
sg              = [illegible] mm               sp         = [illegible] mm
                                               a          = 100.0 mm

Lct             = 0.0 mm                       dct        = 0.0 mm
Lcb             = 0.0 mm                       dcb        = 0.0 mm

Design actions: N* = [illegible] kN compression (Not used)
                Vy* = 53.62 kN (Actual = 53.62 kN, Minimum = 40.00 kN)
                Vz* = -3.46 kN (Not used)
                My* = 12.88 kNm (Not used)
                Mz* = -110.32 kNm (Not used)

Check 1:        Detailing limitations
Weld:           3 mm <= weld size <= 8 mm                              Pass
Bolts:          Gauge in range of 9-14 x plate thickness               Pass
                2 <= rows <= 8                                         Pass
Plate:          Min depth >= 0.6 x beam depth                          Pass
                Min edge distance >= 1.5 x bolt diameter               Pass
                Fits within supporting member's flange                 Pass

Check 2:        Capacity of weld to supporting member
Shear:          Vw = [illegible] kN > V* = 53.62 kN                    Pass

Check 3:        Capacity of bolt group
Shear:          Vb = 555.77 kN > V* = 53.62 kN                         Pass

Check 4:        Capacity of end plate
Shear:          Vp = [illegible] kN > V* = 53.62 kN                    Pass
Bending:        Vd = 514.68 kN > V* = 53.62 kN                         Pass

Check 5:        Capacity of supported member web
Shear:          Vw = 487.32 kN > V* = 53.62 kN                         Pass

Check 6:        Capacity of supported member
Shear:          Vf = 635.60 kN > V* = 53.62 kN                         Pass

Check 7:        Capacity of supported member
                Bending of coped section:
                Section uncoped - check not required

Check 8:        Beam rotation check
                tp / ac > rotation angle                                Pass

Check 9:        Local stability of coped supported member
                Section uncoped - check not required

Check 10:       Local capacity of supporting member
                Check not required
```

The detailed calculations for connection 4

```
CONNECTION 88 - FLEXIBLE END PLATE
----------------------------------

Supporting Member:    33              Strength Grade:       Normal
Supported Member:     150             Strength Grade:       Normal
Member on Other
Side of Web:          [illegible]

Top Cope Depth:       Calculate       Top Cope Length:      Calculate
Bot Cope Depth:       Calculate       Bot Cope Length:      Calculate

Dimensions [illegible]: [illegible]
Plate Strength Grade: [illegible]     [illegible]           [illegible]

Welds:                [illegible]     Weld Category:        SP
Weld Strength Grade:  High

Bolts:                M20             Bolt Procedure:       [illegible]
Bolt Threads:         Include         Bolt Strength Grade:  High
Columns / Rows:       2/3             Top of Beam Dist:     100 mm
Pitch / Gauge:        70 mm/90 mm     Bolt Head Side:       Default

[illegible] DESIGN RESULTS (*[illegible], [illegible])
----------------------  (?-less than minimum design action)
                        (D-Design, C-Check)

                          Plate or                                Crit  Util
 Conn   Title/Type        Seat/Cleat        Bolts    Welds        Case  Ratio

   88 D  Flexible End P... 200.0x150.0x1... 6M20    6.0 mm SP...   12   0.15
                                            8.8N/S

WARNING: There are other design actions not considered for this connection
WARNING: Not all load cases considered have been analysed non-linearly

Design/Check:                                Design
Critical load case:                          12 [illegible]
Utilisation ratio:                           [illegible]           Pass

Supported       = 310 UC 137                 Supporting = 310 UC 137
d               = 321.0 mm                   d          = 321.0 mm
bf              = 309.0 mm                   bf         = 309.0 mm
tf              = [illegible] mm             tf         = [illegible] mm
tw              = 13.8 mm                    tw         = 13.8 mm
r               = 16.5 mm                    r          = 16.5 mm
fyf             = 280.00 MPa                 fyf        = 280.00 MPa
fyw             = 300.00 MPa                 fyw        = 300.00 MPa

Angle           = 0.00°

Plate           = 200.0x150.0x10.0 mm (fy = 260.00 MPa, fu = 410.00 MPa)

Welds           = 6.0 mm [illegible] (fu = 490.00 MPa)

Bolts           = M20 8.8N/S (fu = 830.00 MPa)
Bolt cols       = 2                          Bolt rows  = 3
sg1             = 90.0 mm                    sp         = 70.0 mm
                                             a          = 180.0 mm

Lct             = 150.0 mm                   dct        = 40.0 mm
Lcb             = 347.0 mm                   dcb        = 50.0 mm

Design actions: N*  = 5.92 kN Tension (Not used)
                Vy* = [illegible] (Actual = [illegible], Minimum = 40.00 kN)
                Vx* = 8.25 kN (Not used)
                My* = 17.00 kNm (Not used)
                Mz* = 5.62 kNm (Not used)

Check 1:        Detailing limitations
Welds:          [illegible]                                       Pass
Bolts:          Gauge in range of 9-14 x plate thickness          Pass
                2 <= rows <= 3                                    Pass
Plate:          Min depth >= 50% beam depth                       Pass
                Min edge distance >= 1.5 x bolt diameter          Pass
                [illegible] supporting member's flange            Pass

Check 2:        Capacity of weld to supporting member
Shear:          Vw = 300.35 kN > V* = 40.00 kN                    Pass

Check 3:        Capacity of bolt group
Shear:          Vb = 555.77 kN > V* = 40.00 kN                    Pass

Check 4:        Capacity of end plate
Shear:          Vp = 455.00 kN > V* = 40.00 kN                    Pass
Bearing:        [illegible] > V* = 40.00 kN                       Pass

Check 5:        Capacity of supported member web
Shear:          Vw = 487.25 kN > V* = 40.00 kN                    Pass

Check 6:        Capacity of supported member
Shear:          [illegible] > V* = 40.00 kN                       Pass

Check 7:        Capacity of supported member
                Bending of coped section:
                Vp = 238.20 kN > V* = 40.00 kN                    Pass

Check 8:        Beam rotation check
                tL / ao > rotation angle                          Pass

Cope:           dct, dcb <= 0.2 x d          and
                [illegible]
                [illegible]
                     for d/tw > 300 / sqrt fy)                    Pass

Check 10:       Local capacity of supporting member
Shear           [illegible]
                =1374.09 kN >= V1* x np2/np1 + V2*                Pass
Bearing         min of [no x 5.70 x df x tc x fuc] and
                [no x [illegible] x ae2 x tc x fuc] >= V* =40.00 kN  Pass
                >=                     V1* x np2 / np1)           Pass
```