PHI Low Energy Building

1. ABSTRACT

A two-storey, three-bedroom home located in Northcote, Melbourne, Victoria, architecturally designed to prioritise views to 'All Nations Park' (to the North) with the implementation of the Passive House standard late in the project after the construction of the ground floor concrete slab. This project was aiming for Passive House and achieved the Low-Energy Building standard after undertaking an accredited blower door test achieving a good, though subpar result.

West Elevation of dwelling, showing trees in 'All Nations Park' shading the North

The dwelling reads as part of 'All Nations Park' in Northcote and this is the strong architectural intent of the project from its onset. The second storey has views over the park and the lower storey has private views into the garden to the East. The Western side of the dwelling is protected by fewer (recessed) windows, a carport, with a white weatherboard façade (as pictured above).

1.1. BUILDING DATA

The PHPP has been set to the Low-Energy Building standard and the following data forms the summary at the verification sheet.

Specific building characteristics with reference to the treated floor area

				Criteria	Alternative criteria	Fullfilled?[2]
	Treated floor area m²	192.8				
Space heating	Heating demand kWh/(m²a)	13	≤	30	-	yes
	Heating load W/m²	12	≤	-	-	
Space cooling	Cooling & dehum. demand kWh/(m²a)	-	≤	-	-	-
	Cooling load W/m²	-	≤	-	-	
	Frequency of overheating (> 25 °C) %	4	≤	10		yes
	Frequency of excessively high humidity (> 12 g/kg) %	0	≤	20		yes
Airtightness	Pressurization test result n_{50} 1/h	0.8	≤	1.0		yes
Non-renewable Primary Energy (PE)	PE demand kWh/(m²a)	95	≤	-		-
Primary Energy Renewable (PER)	PER demand kWh/(m²a)	45	≤	75	75	yes
	Generation of renewable energy (in relation to projected building footprint area) kWh/(m²a)	0	≥	-	-	

[2] Empty field: Data missing; '-': No requirement

The PHPP Verification Sheet showing compliant values for the Low-Energy Building standard

- Year of Construction: 2020
- Average U-Value Floor: 0.423 W/(m²K)
- Average U-Value External Wall: 0.247 W/(m²K)
- Average U-Value Roof: 0.181 W/(m²K)
- Exterior Door U-Value: 1.010 W/(m²K)
- Average U-Value North Windows: 1.214 W/(m²K) (Southern Hemisphere South)
- Average U-Value East Windows: 1.089 W/(m²K)
- Average U-Value South Windows: 0.965 W/(m²K) (Southern Hemisphere North)
- Average U-Value West Windows: 1.047 W/(m²K)
- Average U-Value Horizontal Windows: 0.180 W/(m²K)
- Ambient Thermal Bridges (Psi): 0.068 W/(mK)
- Perimeter Thermal Bridges (Psi): 0.139 W/(mK)
- Heat Recovery Efficiency: 81.6%

This dwelling also features Australian Made Timber Windows, including high performance triple-glazed panels made locally.

There is a provision for an Electric Vehicle charger in the carport.

No active cooling was modelled.

Solar PV was not included as the cost of it was prohibitive when compared with the supply of 100% Green Power.

1.2. PROJECT POINTS OF INTEREST

Nestled in a park in Northcote, Melbourne, Victoria, this dwelling had already gained planning and building approval at the time of Antony DiMase inviting Shared Space Architecture to assist with the implementation of the Passive House standard. Typically, it is unadvisable to provide Passive House services this late in the piece, however under the guidance of an experienced architect in Antony (who has had previous Passive House training) and the positive support of a 'can do' attitude in the homeowners, Malcolm and Marj, Antony as well as Nick, the contracted builder, it seemed reasonable to proceed with the calculations.

Nick and Ben from 'Appetite for Construction' agreed to move a wall at one point to achieve better thermal performance; this is an example of the extent the team would go to, ensuring thermal performance intentions were met. It was a privilege to work with this drive and dedication.

The team had also approached Clare Parry for certification of the project.

To begin our preliminary model, we measured and defined the TFA, the areas of the building envelope, the lengths of the thermal bridges, the extent of the shading and the internal air volume. At early stages we typically estimate thermal bridges, however given the timeline we were restricted to and feedback we had to provide quite quickly, it was sensible to calculate all the thermal bridges that came to mind when analysing the thermal envelope. There were over 40 thermal bridge calculations performed to optimise the changes in the thermal envelope components.

When initially engaged, the ground floor slab had already been poured and I instructed to have the builder keep photographic evidence of the installed insulation to present to the certifier at the time of certifications. The concrete slab was insulated with 50mm XPS, which also flanked the footings. Had the opportunity been there to increase the insulation of the slab, slightly less insulation may have been able to be specified in the walls and roof components of the building envelope. However, we rose to the challenge and as a team investigated options to increase certain walls with insulation to mitigate the effects of losses through the concrete slab.

There is a benefit in introducing the Passive House standard at a later part of the process however, in the retention of architectural intent. It was terribly important to maintain excellent views to All Nations Park to the North and maintain views to the garden to the East, this was and remained part of the intent all the way to completion. The downside of this intent from a thermal envelope perspective is the increased heat loss through a larger window area. Fresh air was also seen as beneficial, so a higher number of opening windows remained as a result of discussing options with the architect and homeowner, which had some side effects.

In Australia it is legislated that a dwelling must have 10% of the floor area as window area in bedrooms and living rooms. I usually advise clients to include between 15% and 25% floor area as window area throughout the house; to provide light and also provide enough solar heat gains in cooler climates (like Melbourne). This dwelling had a window area of 36% of the floor area, which meant that insulation had to be increased to around R9.7 in most of the roof and around R8.0 in some upper storey walls. External walls of ground floor bedrooms were also increased to 140mm studs.

We did not use the DesignPH plugin for this project and measured areas in 3D on a program called Cadwork (commonly used for shop documentation and timber machining). After the process was complete and shading modelled manually in the PHPP it was noted that a lot of heat loss came from the Eastern windows/doors at the Ground Floor and a lot of heat gain came from the Eastern door at the first floor. A temporary shading device was introduced to the upper floor door, in line with those already specified for the Western window and Northern Stairwell window.

The construction team tried extremely hard to mitigate air leakage to the extent of engaging an ATTMA airtightness tester on multiple occasions as well as blowing air into the building using a makeshift blower door comprising of pedestal fans on a sheet of OSB – the team was super inventive and proactive. Ultimately the airtightness test did not meet the Passive House standard and I understand there are two main reasons for this.

1. A double internal wall separates the living room from the hallway (upstairs) and hallway from laundry annex (downstairs), the purlins were installed in line with the top of this wall and it was extremely hard to make these airtight. To make things even more difficult a ventilation duct needed to weave from the inside to the outside of the thermal envelope and back in, near to this junction. Tape, Orcon flexible glue and spray airtightness methods were all used to mitigate the air leakage.
2. Window hinges seemed to be the leakiest of all the parts of the windows. A number of times the construction team tried to seal these in different ways. It is likely that the location of the seal under the hinge increased leakiness and the manufacturer appreciated this feedback and may end up looking at ways to rectify this for future projects. Windows are generally the weakest part of any thermal envelope and in hindsight, I understand that the number of opening windows in particular and windows in general may have contributed to unnecessary loss of air at 50 Pascals of pressure.

After the completion of the building around February 2022, the Malcolm had monitored temperature and energy usage of the building and intends to keep an interest in doing so to better understand the physics behind the dwelling and the benefit of the extent we pushed Passive House.

It is unfortunate that the project was unable to realise the Passive House standard, however an important aspect of the verification remains to be upheld. The only criterion which failed the Passive House standard verification is the level of airtightness the dwelling achieves. Changing this number back to 0.6 in the PHPP has no effect on the Heating Demand and Heating Load in the Verification sheet and reduces PER demand by 1 kWh/m^2 p.a.

When considering that the intent of applying the Passive House standard was to limit energy usage and understanding that even though the airtightness level was not achieved, heating demand and heating load remained the same and the PER demand has been met, it can be implied that the goal is achieved.

The best achievement for this project is three-fold and is the architect being able to deliver a home which meets the needs of the homeowner, priorities views to the North of 'All Nations Park' and meets the heating demand, heating load and PER demand of the Passive House standard.

Gratitude and thanks go especially to Antony and the team at DiMase Architects, the Malcolm and Marj and the team at Appetite for Construction for a very interesting implementation of the Low-Energy Building standard from the Passive House Institute.

1.3. RESPONSIBLE PROJECT PARTICIPANTS

- Architect: Antony DiMase, DiMase Architects (https://dimasearchitects.com.au)
- Passive House Implementation and Planning: Alex Slater, Building Physics Australia (Shared Space Architecture) (https://buildingphysics.au)
- Building Systems: Steve Rodwell, Enterprise Air (https://enterpriseair.net.au)
- Building Physics (Thermal Bridge Modelling): Alex Slater, Building Physics Australia (Shared Space Architecture) (https://buildingphysics.au)
- Engineering: David Hogg, Quatrefoil Consulting (https://quatrefoil.com.au/)
- Landscape Design: Jacqueline McWilliam, Avantgardener (https://www.avantgardener.com.au)
- Construction Management: Nick Lightfoot, Appetite for Construction (http://www.appetiteforconstruction.com.au)
- Airthightness Tester: Ryan Parkes, Ryan Parkes Building (https://www.ryanparkesbuilding.com.au)
- Certifying Body: Clare Parry, Grün Consulting (part of Inhabit Group) (https://inhabitgroup.com)

Passive House Project Database ID: 7141

(https://passivehouse-database.org/index.php?lang=en#d_7141)

Parties authoring project documentation are: DiMase Architects, Building Physics Australia and Building Systems.

Report authored by Alex Slater.

6th January 2023

(updated 17th May 2023)

2. ARCHITECTURAL CONCEPT

Designed for view the homeowners approached DiMase Architects to explore their brief of three main points; these three are:

1. A house that suits their needs
2. A house that makes the most of the perspective onto the neighbouring 'All Nations Park'
3. A house that is energy efficient

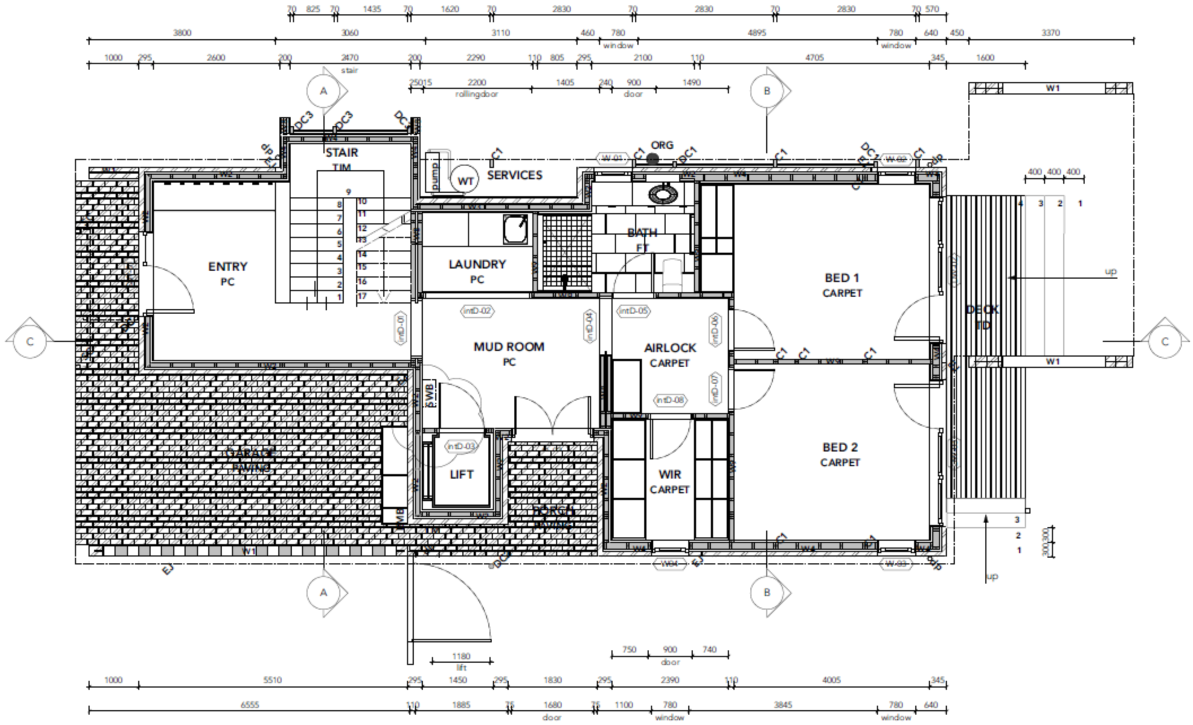
The house is designed on a reverse-living arrangement with the living spaces upstairs along with the study. It has a lift to ensure access is granted to those with limited ability and future-proofing the dwelling as the homeowners age.

To address the needs of the homeowners, the arrangement of the house allows for both levels to be fairly usable independently of the other. Both levels contain a bathroom and bedroom and both have spaces which could be used as separate living areas. Another need is access, for which there is a lift between the two levels.

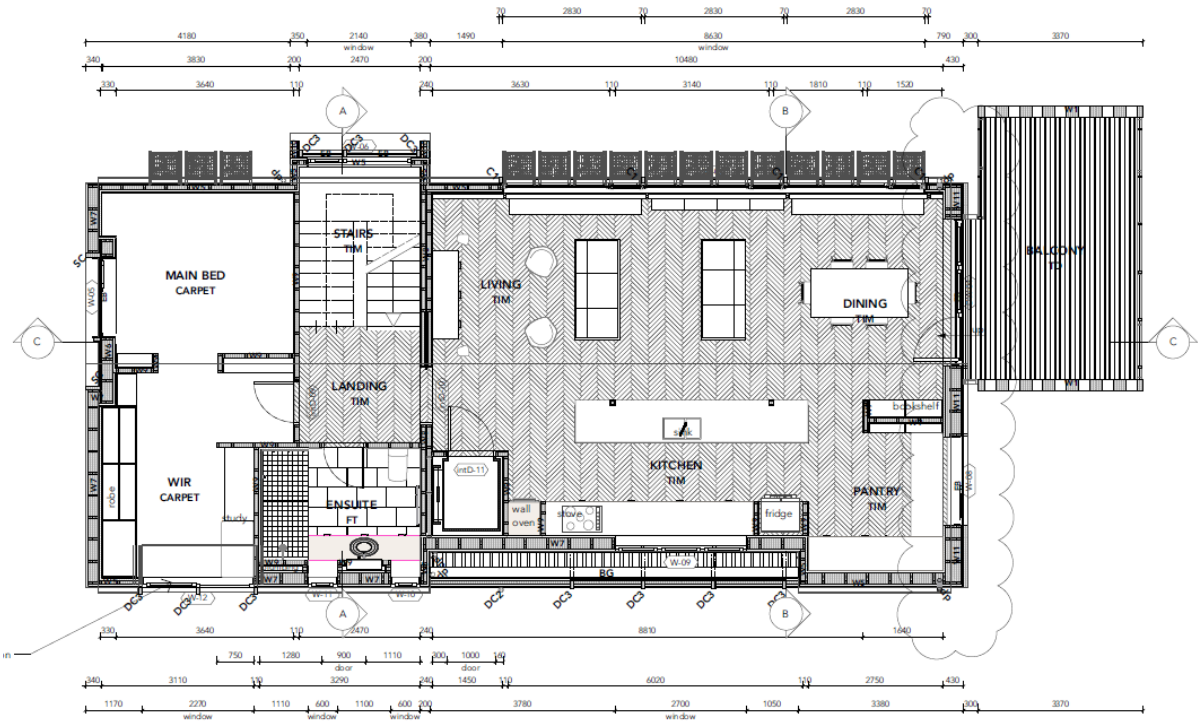
Delight is also presented in the views to the Garden and landscaping concept which along with vegetation in 'All Nations Park', presents some excellent opportunities to keep the dwelling cool to the North and East.

To make the most of the perspective onto the neighbouring 'All Nations Park', a full width window has been included in the living area facing the North. A further window has been incorporated into the stairwell, being taller, allowing for views from both the ground floor and the first floor levels.

The dwelling is certainly one which is comfortable, accessible and delightful, and demonstrates the benefit of engaging an experienced architect along with the Passive House process.



Ground Floor Plan from DiMase Architects



First Floor Plan from DiMase Architects

3. CONSTRUCTION ASSEMBLIES

A number of construction assemblies were used to accommodate the necessity to insulate to a high level, balancing the window area and uninsulated slab, these are:

- 125mm Slab East Stair (U-Value 0.874 W/(m²K))
- 200mm Timber Floor (U-Value 0.275 W/(m²K))
- 90mm Stud EXT Wall (U-Value 0.302 W/(m²K))
- Timber Framed Roof (U-Value 0.151 W/(m²K))
- Timber Framed Roof under Metal Structure (U-Value 0.302 W/(m²K))
- 230mm Double Stud EXT Wall (U-Value 0.157 W/(m²K))
- 140mm Stud EXT Wall (U-Value 0.231 W/(m²K))
- Stair Bulkhead Wall (U-Value 0.361 W/(m²K))
- Stair Bulkhead Ceiling (U-Value 0.460 W/(m²K))
- 125mm Slab Entry (U-Value 0.727 W/(m²K))
- Upper Floor Overhang (U-Value 0.228 W/(m²K))
- Timber Framed Roof no GreenStuf (U-Value 0.218 W/(m²K))

3.1. 125MM SLAB EAST STAIR

Because the slab was installed prior to commencing analysis in the PHPP. I tried a few options to balance out the 50mm of XPS flanking the sides of the footings, however not under the footings. This produced a conservative estimate and today I would look at this a little differently and estimate a thermal bridge for the slab beams.

The slab consists of a 125mm layer of concrete and a 50mm layer of XPS

Assembly no.	Building assembly description	Interior insulation?
01ud	125mm Slab East Stair	

Orientation of building element	3-Floor	Heat transmission resistance [m²K/W] interior R_{si}	0.13
Adjacent to	2-Ground	exterior R_{se}	0.00

Area section 1	λ [W/(mK)]	Area section 2 (optional)	λ [W/(mK)]	Area section 3 (optional)	λ [W/(mK)]	Thickness [mm]
Calculated Composite	0.592					600
see 'CALCS'						

Percentage of sec. 1	Percentage of sec. 2	Percentage of sec. 3	Total
100%			60.0 cm

U-value supplement		W/(m²K)	U-value:	0.874	W/(m²K)

3.2. 200MM TIMBER FLOOR

The timber floor extends from the slab to the East and is predominantly under the ground floor bedrooms. It comprises of an 18mm floorboard, 200mm MGP 10 (Pine) Joists and a 195mm (R4.0) layer of Earthwool insulation. An airgap has been modelled as the joists are deeper than the insulation.

Assembly no.	02ud	200mm Timber Floor	Interior insulation?
Orientation of building element	3-Floor	Heat transmission resistance [m²K/W] interior R_{si}:	0.13
Adjacent to	1-Outdoor ai	exterior R_{se}:	0.04

Area section 1	λ [W/(mK)]	Area section 2 (optional)	λ [W/(mK)]	Area section 3 (optional)	λ [W/(mK)]	Thickness [mm]
Floorboard	0.180					18
Air Gap	0.270	Timber Joists	0.130			5
Knauf Earthwool R4.0	0.049	Timber Joists	0.130			195
Percentage of sec. 1	88%	Percentage of sec. 2	12.3%	Percentage of sec. 3		Total 21.8 cm
U-value supplement		W/(m²K)		U-value:	0.275	W/(m²K)

3.3. 90MM STUD EXT WALL

Some walls were locked in at 90mm before commencing the PHPP analysis. In order to increase the performance of these walls, the 45mm batten layer was insulated. The wall comprises R2.7 insulation in the 90mm stud layer and R1.3 in the 45mm service batten layer.

Assembly no.	03ud	90mm Stud EXT Wall	Interior insulation?
Orientation of building element	2-Wall	Heat transmission resistance [m²K/W] interior R_{si}:	0.13
Adjacent to	1-Outdoor ai	exterior R_{se}:	0.04

Area section 1	λ [W/(mK)]	Area section 2 (optional)	λ [W/(mK)]	Area section 3 (optional)	λ [W/(mK)]	Thickness [mm]
Bradford Gold High Performance R2.7	0.033	Timber Studs and Noggings	0.130			90
Greenstuff R1.3	0.035			Timber Service Batten	0.130	45
Percentage of sec. 1	71%	Percentage of sec. 2	13.0%	Percentage of sec. 3	15.6%	Total 13.5 cm
U-value supplement		W/(m²K)		U-value:	0.302	W/(m²K)

3.4. TIMBER FRAMED ROOF

The roof is thermally working very hard to compensate for reduced insulation in the lower floor. It comprises of two layers of insulation (R7.0 + R2.7) supported by 190mm purlins and 90mm raked ceiling battens.

Assembly no.						Interior insulation?
04ud	Timber Framed Roof					
		Heat transmission resistance [m²K/W]				
Orientation of building element	1-Roof	interior R_{si}:	0.13			
Adjacent to	1-Outdoor ai	exterior R_{se}:	0.04			

Area section 1	λ [W/(mK)]	Area section 2 (optional)	λ [W/(mK)]	Area section 3 (optional)	λ [W/(mK)]	Thickness [mm]
Bradford Gold Hi-Performance R7.0	0.041	Timber Purlins and Blocks	0.130	Roof Beams	0.180	190
Bradford Gold Hi-Performance R7.0	0.041	100mm Air Gap	0.610	Roof Beams	0.180	100
Bradford Gold Hi-Performance R2.7	0.033	Timber Purlins and Blocks	0.130			90
*wanting to remove						
Percentage of sec. 1	84%	Percentage of sec. 2	13.0%	Percentage of sec. 3	3.0%	Total 38.0 cm
U-value supplement		W/(m²K)		**U-value:**	**0.151**	W/(m²K)

3.5. TIMBER FRAMED ROOF UNDER METAL STRUCTURE

The structural detail at the Northern Shade meant that it sat under the 190mm purlin layer. In order to increase performance, an additional R1.3 layer was added above along with timber battens to support this layer.

Assembly no.						Interior insulation?
05ud	Timber Framed Roof under Metal Structure					
		Heat transmission resistance [m²K/W]				
Orientation of building element	1-Roof	interior R_{si}:	0.13			
Adjacent to	1-Outdoor ai	exterior R_{se}:	0.04			

Area section 1	λ [W/(mK)]	Area section 2 (optional)	λ [W/(mK)]	Area section 3 (optional)	λ [W/(mK)]	Thickness [mm]
Greenstuff R1.3	0.035			Timber Battens	0.130	45
Bradford Gold Hi-Performance R2.7	0.033	Timber Rafter	0.130			90
*wanting to remove						
Percentage of sec. 1	71%	Percentage of sec. 2	13.0%	Percentage of sec. 3	15.6%	Total 13.5 cm
U-value supplement		W/(m²K)		**U-value:**	**0.302**	W/(m²K)

3.6. 230MM DOUBLE STUD EXT WALL

The upper storey walls facing the East and West were required to thermally work hard to cater for the lower performance in the lower storey. An architectural detail was used to clad the structural 140mm wall with an additional 90mm wall before applying timber cladding. The insulation comprises an R4.0, R2.7 layer and R1.3 in the service cavity.

Assembly no.		Interior insulation?
06ud	230mm Double Stud EXT Wall	

Heat transmission resistance [m²K/W]

Orientation of building element	2-Wall	interior R_{si}:	0.13
Adjacent to	1-Outdoor ai	exterior R_{se}:	0.04

Area section 1	λ [W/(mK)]	Area section 2 (optional)	λ [W/(mK)]	Area section 3 (optional)	λ [W/(mK)]	Thickness [mm]
Bradford Gold High Performance R4	0.035	Timber Studs and Noggins	0.130			140
Bradford Gold High Performance R2.7	0.033	Timber Studs and Noggins	0.130			90
Greenstuff R1.3	0.035			Timber Battens	0.130	45
*wanting to remove						
Percentage of sec. 1	71%	Percentage of sec. 2	13.0%	Percentage of sec. 3	15.6%	Total 27.5 cm

U-value supplement: W/(m²K)

U-value: 0.157 W/(m²K)

3.7. 140MM STUD EXT WALL

During design discussions, a 140mm stud wall was able to be allowed for in the ground floor bedrooms (R4.0). This also had an insulated cavity (R1.3).

Assembly no.		Interior insulation?
07ud	140mm Stud EXT Wall	

Heat transmission resistance [m²K/W]

Orientation of building element	2-Wall	interior R_{si}:	0.13
Adjacent to	1-Outdoor ai	exterior R_{se}:	0.04

Area section 1	λ [W/(mK)]	Area section 2 (optional)	λ [W/(mK)]	Area section 3 (optional)	λ [W/(mK)]	Thickness [mm]
Bradford Gold R4.0	0.035	Timber Studs and Noggins	0.130			140
GreenStuf R1.3	0.035			Timber Studs	0.130	45
*wanting to remove						
Percentage of sec. 1	71%	Percentage of sec. 2	13.0%	Percentage of sec. 3	15.6%	Total 18.5 cm

U-value supplement: W/(m²K)

U-value: 0.231 W/(m²K)

3.8. STAIR BULKHEAD WALL

Above the stair window is a small 90mm wall backed onto a ventilated cavity. It comprises the same buildup as other 90mm walls in the project, being R2.7 insulation in the stud layer and R1.3 in the service cavity.

Assembly no.						Interior insulation?
08ud	Stair Bulkhead Wall					
		Heat transmission resistance [m²K/W]				
Orientation of building element	2-Wall	interior R_{si}:	0.13			
Adjacent to	3-Ventilated	exterior R_{se}:	0.13			
Area section 1	**λ [W/(mK)]**	**Area section 2 (optional)**	**λ [W/(mK)]**	**Area section 3 (optional)**	**λ [W/(mK)]**	**Thickness [mm]**
Bradford Gold R2.7	0.033	Timber Stud	0.130	Timber T/B Plate	0.130	90
GreenStuf R1.3	0.035			Timber Studs	0.130	45
Percentage of sec. 1	71%	Percentage of sec. 2	13.0%	Percentage of sec. 3	15.6%	Total 13.5 cm
U-value supplement		W/(m²K)		U-value:	0.361	W/(m²K)

3.9. STAIR BULKHEAD CEILING

The bulkhead ceiling has R2.7 installed between the ceiling joists and is adjacent to a ventilated cavity.

Assembly no.						Interior insulation?
09ud	Stair Bulkhead Ceiling					
		Heat transmission resistance [m²K/W]				
Orientation of building element	1-Roof	interior R_{si}:	0.13			
Adjacent to	3-Ventilated	exterior R_{se}:	0.13			
Area section 1	**λ [W/(mK)]**	**Area section 2 (optional)**	**λ [W/(mK)]**	**Area section 3 (optional)**	**λ [W/(mK)]**	**Thickness [mm]**
Bradford Gold Hi-Performance R2.7	0.033	Timber Purlin	0.130			90
Percentage of sec. 1	84%	Percentage of sec. 2	15.6%	Percentage of sec. 3		Total 9.0 cm
U-value supplement		W/(m²K)		U-value:	0.460	W/(m²K)

3.10. 125MM SLAB ENTRY

Similar to the 125mm slab to the East of the Stairs, this slab was calculated in THERM. It has a slightly better performance as there are fewer concrete beams.

Assembly no.							Interior insulation?
10ud	125mm Slab Entry						
Orientation of building element	3-Floor	Heat transmission resistance [m²K/W] interior R_{si}	0.13				
Adjacent to	2-Ground	exterior R_{se}	0.00				
Area section 1	λ [W/(mK)]	Area section 2 (optional)	λ [W/(mK)]	Area section 3 (optional)	λ [W/(mK)]		Thickness [mm]
Calculated Composite	0.482						600
see 'CALCS'							
Percentage of sec. 1	100%	Percentage of sec. 2		Percentage of sec. 3		Total	60.0 cm
U-value supplement		W/(m²K)		U-value:	0.727	W/(m²K)	

3.11. UPPER FLOOR OVERHANG

The upper floor consists of 240mm timber joists (MGP10 Pine) and is insulated with R5.0 fibreglass insulation. The supporting floorboard is 18mm.

Assembly no.							Interior insulation?
11ud	Upper Floor Overhang						
Orientation of building element	3-Floor	Heat transmission resistance [m²K/W] interior R_{si}	0.13				
Adjacent to	1-Outdoor ai	exterior R_{se}	0.04				
Area section 1	λ [W/(mK)]	Area section 2 (optional)	λ [W/(mK)]	Area section 3 (optional)	λ [W/(mK)]		Thickness [mm]
Floorboard	0.180						18
Bradford Gold R5.0	0.048	Timber Joists and Plates	0.130				240
Percentage of sec. 1	87%	Percentage of sec. 2	13.0%	Percentage of sec. 3		Total	25.8 cm
U-value supplement		W/(m²K)		U-value:	0.228	W/(m²K)	

3.12. TIMBER FRAMED ROOF NO GREENSTUF

Above the ensuite we were unable to apply an extra layer and GreenStuf to the roof buildup. This roof buildup contains one layer of R7.0 roof insulation, a 190mm timber purlin and associated air gap under the purlin.

Assembly no.						Interior insulation?
16ud	Timber Framed Roof no GreenStuf					
		Heat transmission resistance [m²K/W]				
Orientation of building element	1-Roof	interior R_{si}:	0.13			
Adjacent to	1-Outdoor ai	exterior R_{se}:	0.04			
Area section 1	**λ [W/(mK)]**	**Area section 2 (optional)**	**λ [W/(mK)]**	**Area section 3 (optional)**	**λ [W/(mK)]**	**Thickness [mm]**
Bradford Gold Hi-Performance R7.0	0.041	Timber Purlins and Blocks	0.130	Roof Beams	0.180	190
Bradford Gold Hi-Performance R7.0	0.041	100mm Air Gap	0.610	Roof Beams	0.180	100
Percentage of sec. 1	84%	Percentage of sec. 2	13.0%	Percentage of sec. 3	3.0%	Total 29.0 cm
U-value supplement		W/(m²K)		U-value:	0.218	W/(m²K)

4. THERMAL BRIDGES

The PH method used to determine the losses through thermal bridges was to model all those above 0.010 W/(mK). Due to the number of Construction Assemblies, there are quite a number of thermal bridges which are listed in the PHPP. Given that the decision to aim for the Passive House standard was arrived at after the construction of the slab all thermal bridges were calculated at very early stage rather than estimating. I understand that there were over 30 calculations performed to ensure that the correct advice was provided. Below is a description, value and image of the thermal bridges included in the calculations in the PHPP.

1. 90mm to DS Vertical Liftwell (0.097 W/(mK))
2. Floor Overhang 90mm (0.103 W/(mK))
3. Floor Overhang 140mm 90mm (0.092 W/(mK))
4. Floor Overhang 140mm DS (0.074 W/(mK))
5. Gutter Edge Under Shade (0.132 W/(mK))
6. Lower Wall to Floor Sandwich (0.071 W/(mK))
7. Roof Ridge (0.018 W/(mK))
8. Roof to Shade Structure (0.019 W/(mK))

9. Stair Roof to Upper Wall (0.188 W/(mK))
10. Straight 140 to 90mm Stud (0.061 W/(mK))
11. Straight DS to 90mm Stud (0.068 W/(mK))
12. WIR Roof to 90mm Upper Wall (0.065 W/(mK))
13. WIR Roof to DS Upper Wall (0.031 W/(mK))
14. Concrete Slab Perimeter (0.217 W/(mK))
15. Concrete Slab to Carport (0.215 W/(mK))
16. Timber Floor Perimeter 140mm (0.040 W/(mK))

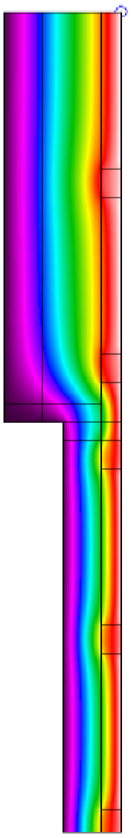
There are also a few penetrations which needed to be taken into account. No THERM model was produced for these and they were calculated using methods described in the PHPP Manual.

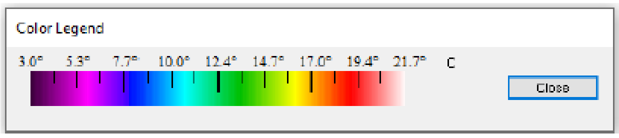
- Basin 40mm (0.191 W/(mK))
- Floor Waste 65mm (0.305 W/(mK))
- Kitchen Sink 50mm (0.237 W/(mK))
- Shower 50mm (0.237 W/(mK))
- WC 100mm (0.463 W/(mK))

4.1. 90MM TO DS VERTICAL LIFTWELL

The Liftwell has no floor overhang and needed to be calculated separately. The wall above is 140mm to balance out reduced insulation in the lower floor walls.

Psi: 0.061 W/(mK); FRsi: 0.89

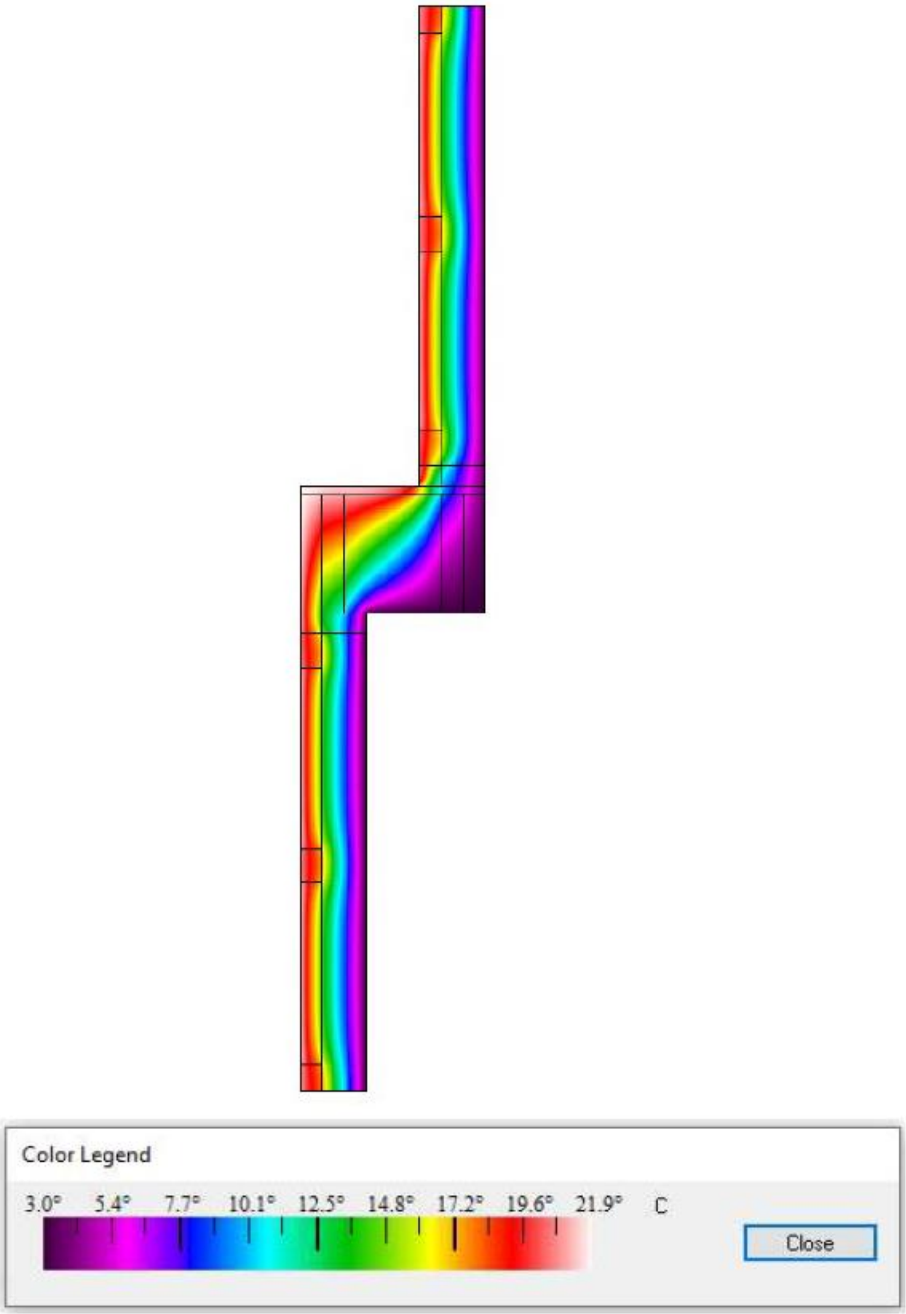




4.2. FLOOR OVERHANG 90MM

For this dwelling, the whole thermal bridge was calculated over the floor overhand, thus negating the need to include additional area on the underside of the overhang. This method ensured the model was not overly conservative at this junction of the thermal envelope.

Psi: 0.103 W/(mK); FRsi: 0.73



4.3. FLOOR OVERHANG 140MM 90MM

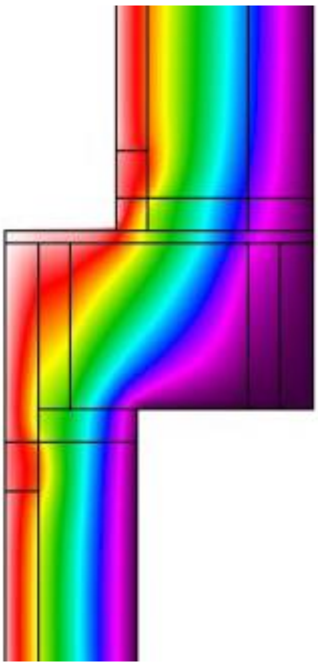
At the ground floor bedrooms in particular an additional thermal bridge needed to be calculated as the ground floor walls comprised of 140mm studs. The thermal model is similar to that above '4.2. Floor Overhang 90mm'

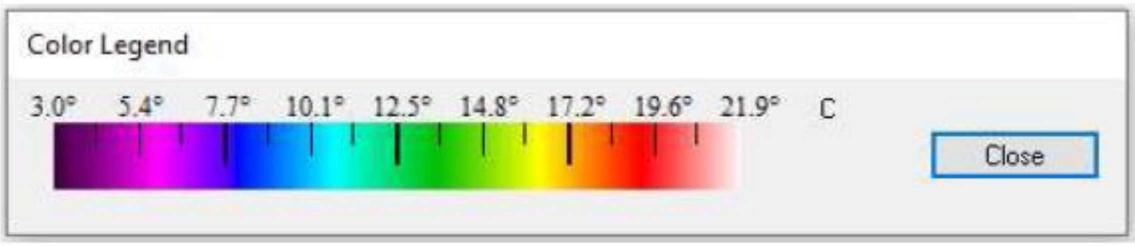
Psi: 0.092 W/(mK); FRsi: 0.73

4.4. FLOOR OVERHANG 140MM DS

Similarly, this thermal bridge detail is consistent with '4.2. Floor Overhang 90mm'. It is detailed on the upper floor East and West walls, where a 90mm wall flanks the outside of a 140mm stud wall. The flanking was requires, as previously mentioned to compensate for reduced insulation in the lower floor walls.

Psi: 0.074 W/(mK); FRsi: 0.85

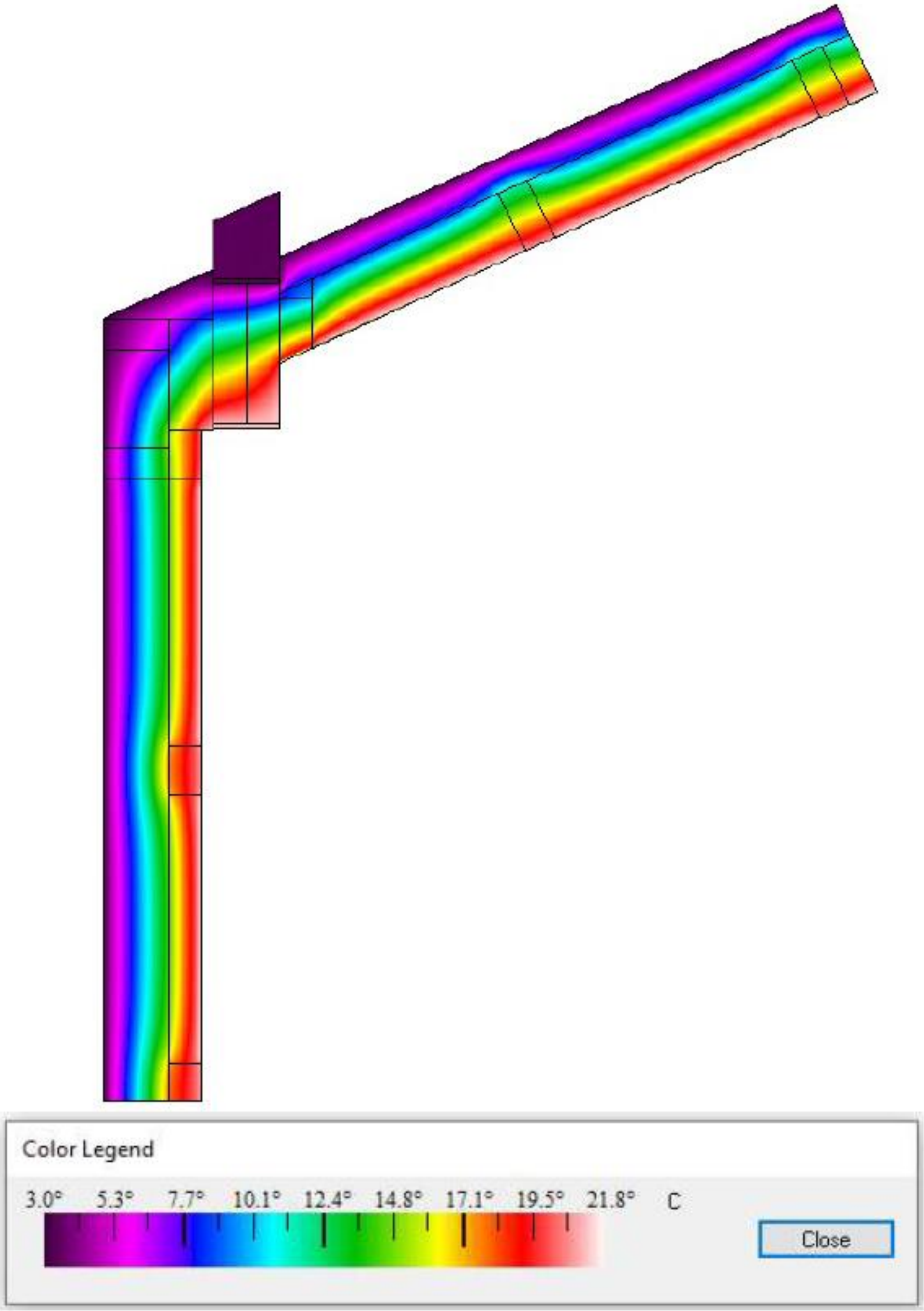




4.5. GUTTER EDGE UNDER SHADE

The windows looking North to All Nations Park are full width and some detailing was required around the necessity to hold up a roof and a shading device. The solution included a round column, supporting a timber lintel to which was attached a steel bracket to support the metal structure of the shading device.

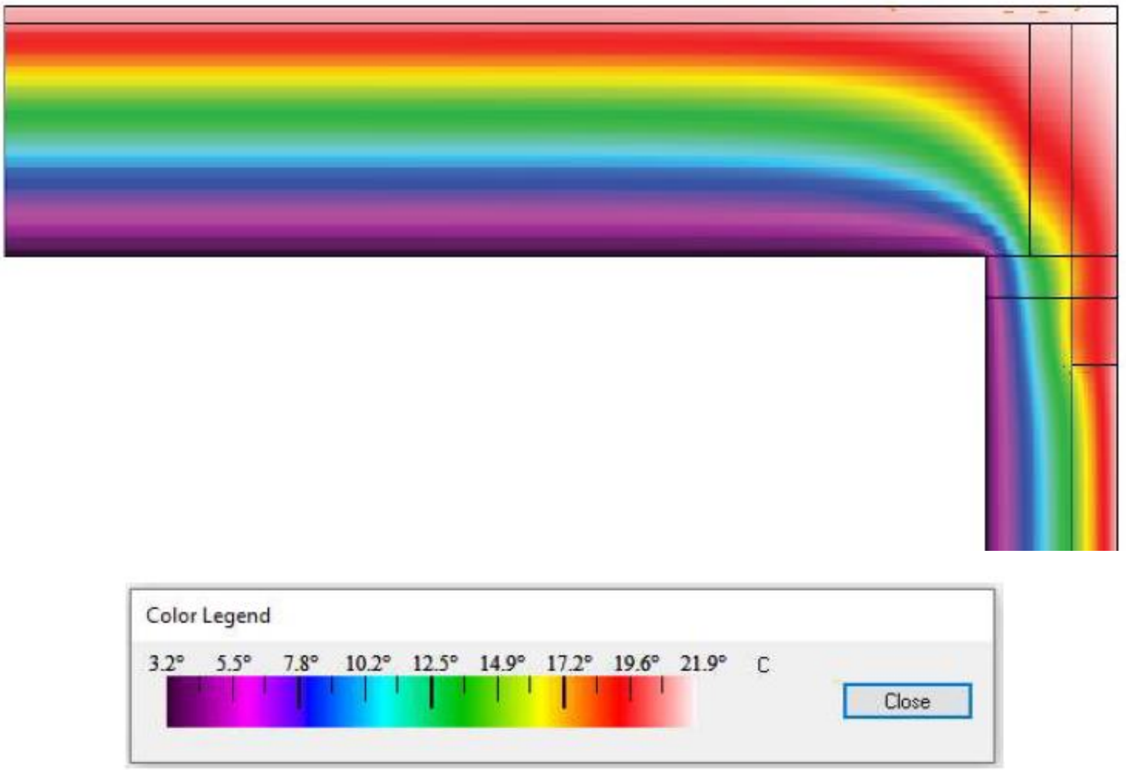
Psi: 0.132 W/(mK); FRsi: 0.71



4.6. LOWER WALL TO FLOOR SANDWICH

This thermal bridge connects the carport ceiling to the surrounding 90mm stud walls. On the outside of the stud walls is a brick layer exposed to the elements.

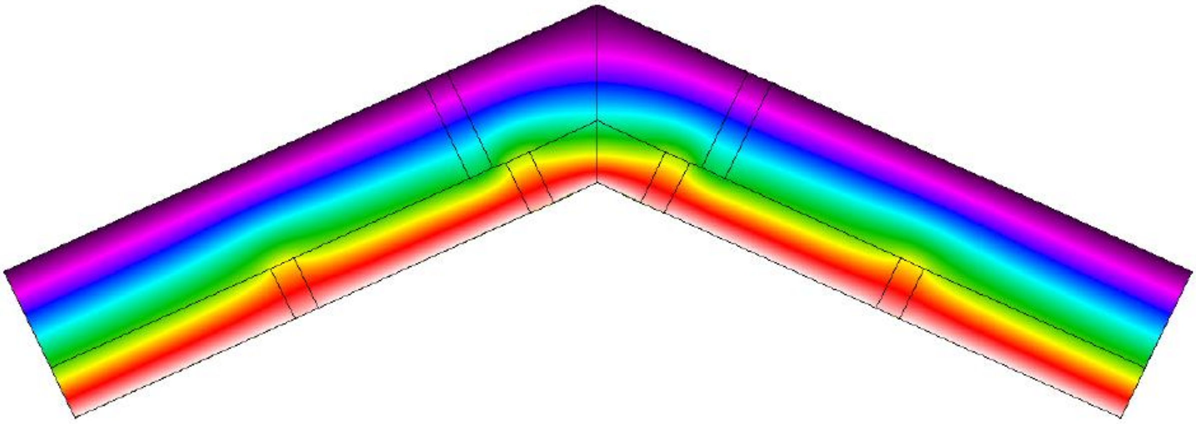
Psi: 0.071 W/(mK); FRsi: 0.88



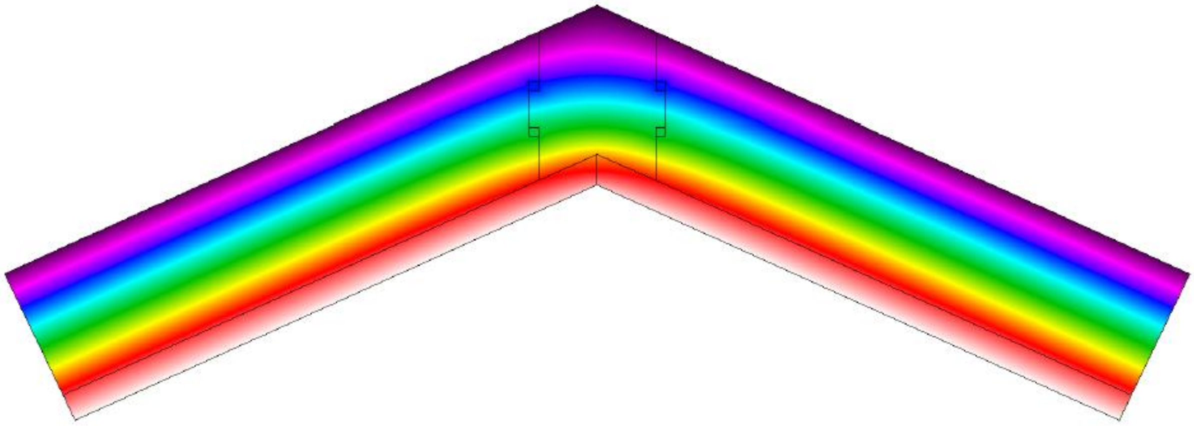
4.7. ROOF RIDGE

To calculate this thermal bridge, three sections were taken. Insulation without purlins, a purlin cross section (including bolts) and a metal plate cross section (as purlins were connected using metal plates, avoiding excessive columns and beams in the living space. A ratio calculated based on the spacing of the purlins and their thickness and the thickness of the steel plate.

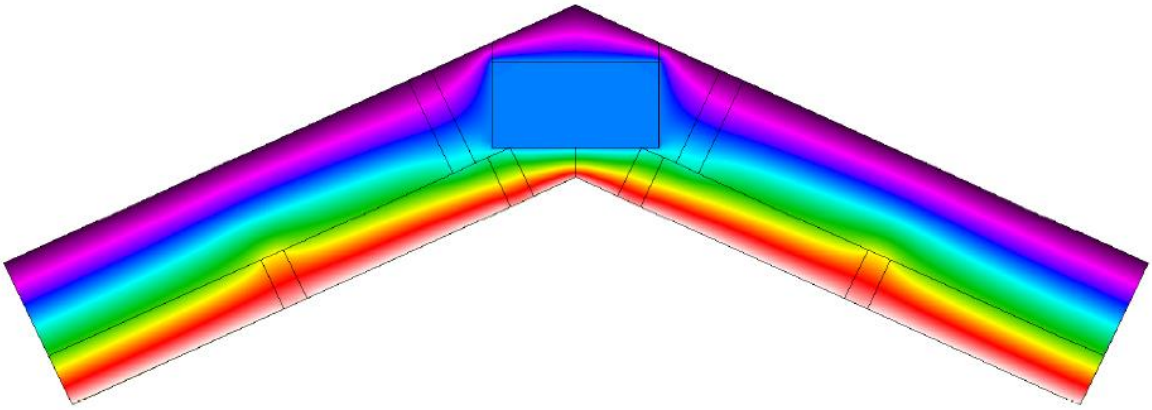
Psi: 0.018 W/(mK); FRsi: 0.76



Cross-Section of Insulation between purlins



Cross-Section through purlins

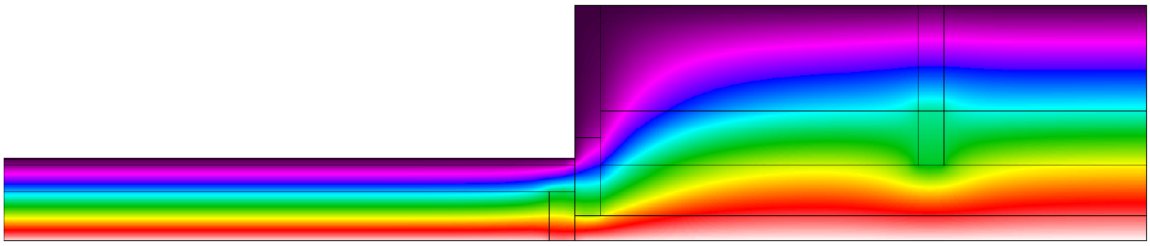


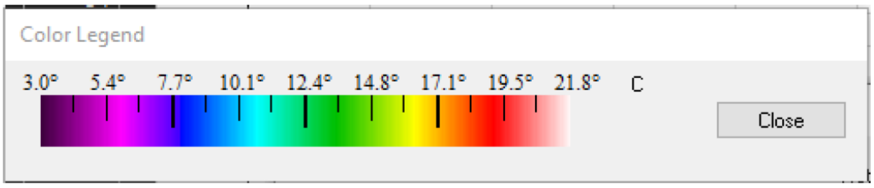
Cross-Section through Steel Plate

4.8. ROOF TO SHADE STRUCTURE

In order to support metal outriggers to support textured sheets to shade the Northern windows, a reduced thermal envelope was required. The outriggers sit in the space above the thinner roof plane.

Psi: 0.019 W/(mK); FRsi: 0.84

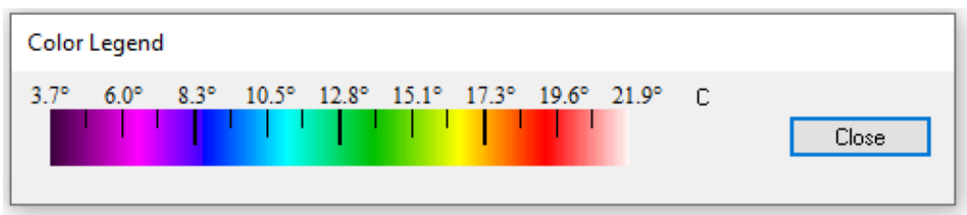




4.9. STAIR ROOF TO UPPER WALL

The roof above the stair well protrusion sat lower and took the line of the shade structure of the Northern windows in the upstairs living area. The remaining height is similar to that of the lintel required to support the roof above the Northern windows.

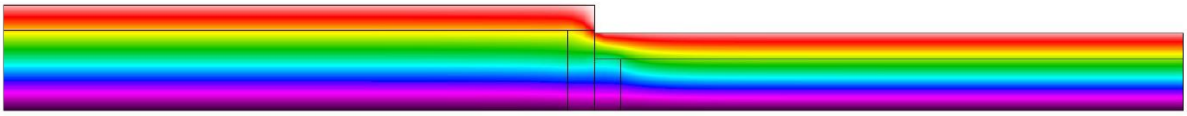
Psi: 0.188 W/(mK); FRsi: 0.91

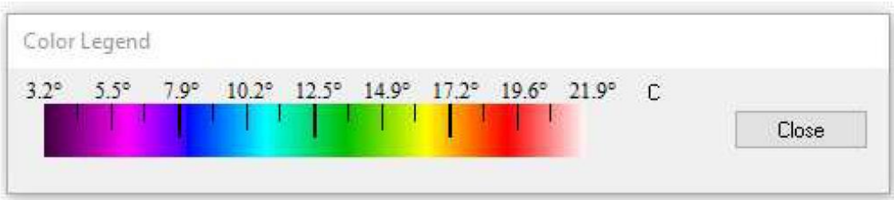


4.10. STRAIGHT 140MM TO 90MM STUD

A plan detail to assess the gemetric change between 90mm and 14mm studs throughout the building envelope. It shows that there are inefficiencies in changing the thermal envelope, however changing the envelope was required due to spatial constrains required to satisfy internal spaces and planning requirements.

Psi: 0.061 W/(mK); FRsi: 0.78





4.11. STRAIGHT DS TO 90MM STUD

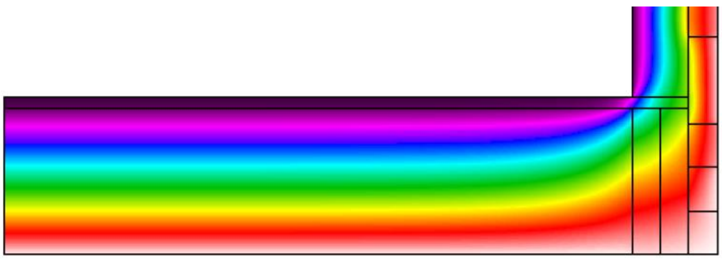
Similar to '4.10. Straight 140mm to 90mm Stud', this detail is situated at the upstairs Ensuite. The Ensuite was able to accommodate a thicker wall to compensate for less insulation elsewhere in the thermal envelope and maximise area in the study.

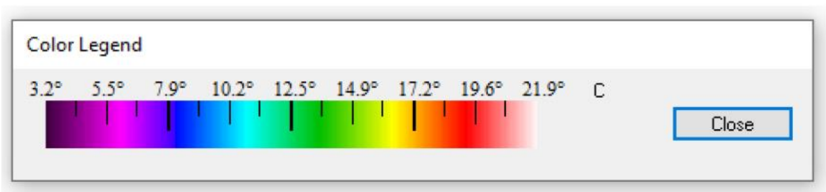
Psi: 0.068 W/(mK); FRsi: 0.56

4.12. WIR ROOF TO 90MM UPPER WALL

Above the WIR there is an exposed ceiling (just below the Kitchen window). The East and West walls of the niche had to remain at 90mm studs.

Psi: 0.065 W/(mK); FRsi: 0.90





4.13. WIR ROOF TO DS UPPER WALL

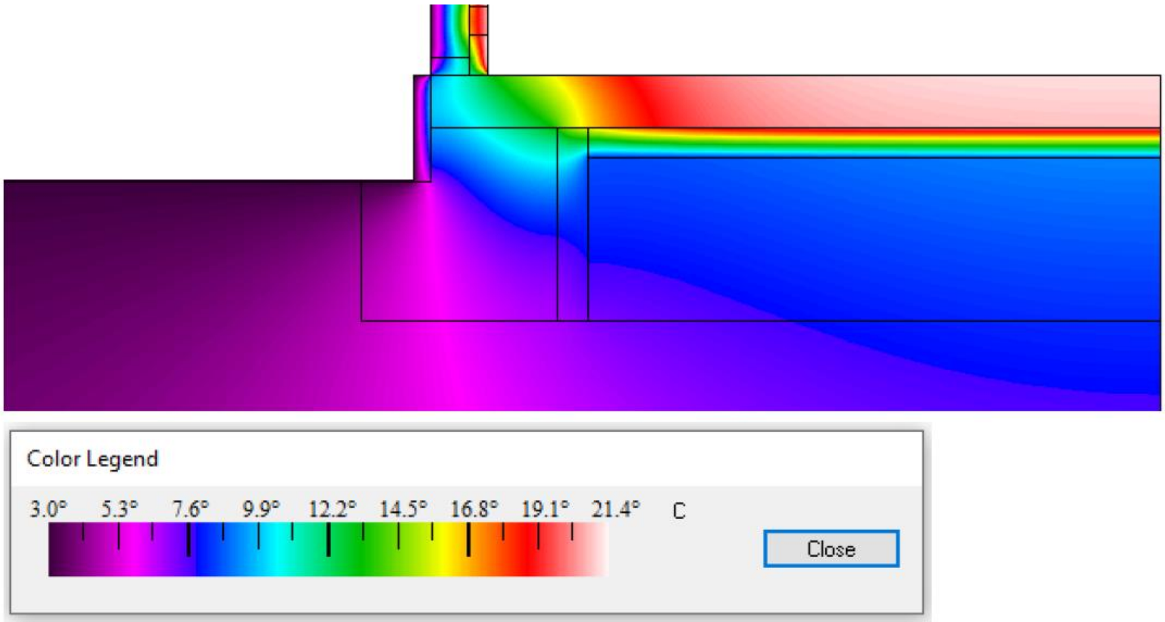
Similar to '4.12. WIR Roof to 90mm Upper Wall', this detail was required for the Northern wall of the Niche as the Kitchen could cater for extra external wall thickness to assist in balancing the building envelope.

Psi: 0.031 W/(mK); FRsi: 0.94

4.14. CONCRETE SLAB PERIMETER

As the slab was constructed prior to investigating the design using the PHPP, the thermal bridge is quite large, however still adequate to deflect heat flow away from the internal environment. An improvement would be to either flank the whole outside of the footing or install a load-bearing insulation strip or both. A Rebate was required to support the outer-skin brickwork.

Psi: 0.217 W/(mK); FRsi: 0.61



4.15. CONCRETE SLAB TO CARPORT

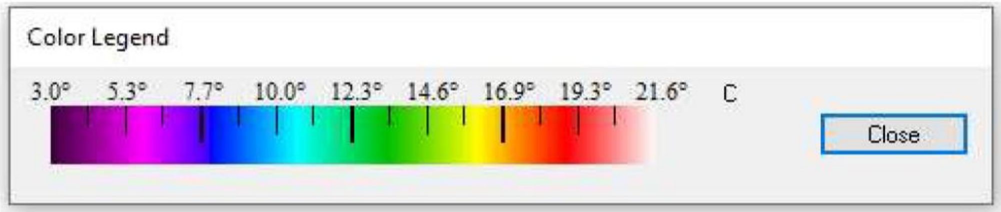
Similar to '4.14 Concrete Slab Perimeter', this thermal bridge models the addition of a concrete slab at the carport above an additional adjacent footing.

Psi: 0.215 W/(mK); FRsi: 0.61

4.16. TIMBER FLOOR PERIMETER 140MM

Beyond the slab, a 200mm timber floor was constructed mainly under the ground floor bedrooms. The bedrooms had 140mm stud walls to increase the insulative properties and compensate for losses in other parts of the thermal envelope.

Psi: 0.040 W/(mK); FRsi: 0.74



5. WINDOWS

It was the wish of the homeowner and architect to install locally manufactured windows into this dwelling. Paarhammer windows were used throughout with high performance glass from Viridian, recommended by the Passive House Certifier. The window frames are timber (Victorian Ash). The internal and external surfaces of the windows were painted. Flyscreens were added to opening windows, consisting of a timber frame and metal flywire.

Due to the requirement of Northern views to All Nations Park, three full-height sliding doors to the East and a Roof Window at the Study, facing the South, the window area to floor area was relatively high at 36%, this resulted in the requirement to use a higher performance glazing unit as views were a priority and the planning permit had already been issued.

The following are values of the windows and we needed to calculate them and the install thermal bridges in order to put them in the PHPP for verification.

5.1. WINDOW INPUTS

Paarhammer Fixed Window

- Width (all frames): 74mm
- U-Value (TopLR): 1.48 W/m²K
- U-Value (Bottom): 1.53 W/m²K

Paarhammer Opening Window

- Width (TopLR): 120mm
- Width (Bottom): 147mm
- U-Value (TopLR): 1.48 W/m²K
- U-Value (Bottom): 1.53 W/m²K

Paarhammer Glazed Door

- Width (TopLR): 158mm
- Width (Bottom): 188mm
- U-Value (TopLR): 1.59 W/m²K
- U-Value (Bottom): 1.45 W/m²K

Paarhammer Roof Window

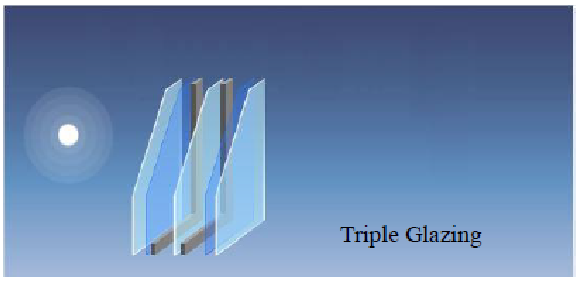
- Width (TopLR): 80mm
- Width (Bottom): 262mm
- U-Value (TopLR): 0.96 W/m²K
- U-Value (Bottom): -0.91 W/m²K (mullion with W12)

Note: The roof window was installed above the frame of an opening and fixed window and a thermal bridge calculation included both the base of the roof window and the top of the fixed and opening Windows. The U-Value of the top of the fixed and opening windows was subtracted from this calculation resulting in a negative thermal bridge.

5.2. GLAZING

The Glazing selected achieves a U-Value (U_g) of 0.5 and Solar Factor (g) of 54%. It is made in Melbourne by Viridian and allowed us to achieve the higher performance we required to offset the reasonably large glazing area in the thermal envelope and lower performance values locked in in other parts of the envelope.

Monday, 29 April 2019
Conditions of Analysis – EN410 (2011-04) and EN673 (2011)



IGU Make-up	
Pane 1	4mm Clear
Coating(2)	LuxTech
Cavity 1	18mm Argon
Pane 2	4mm Clear
Cavity 2	18mm Argon
Coating(5)	LuxTech
Pane 3	4mm Clear

Summary of Insulated Glazing Unit provided by Viridian

Luminous Factors EN410 (2011-04)	
Light Transmittance (TL)	74%
Outdoor Reflectance (RLe)	14%
Indoor Reflectance (RLi)	14%
Thermal Transmission EN673-2011	
Ug	0.5 W/(m^2 .K)
0° related to vertical position	
Manufacturing sizes	
Nominal Thickness	48mm
Weight	30 kg/m^2
Acoustics EN12758	
$R_w(C, C_{tr})$	32 (-1, -5) dB
UV Factors EN410 (2011-04)	
TUV	22%

Energy Factors EN410 (2011 – 04)	
Transmittance (TE)	48%
Outdoor Reflectance (REe)	32%
Indoor Reflectance (REi)	32%
Absorptance A1(AE1)	11%
Absorptance A2	4%
Absorptance A3	5%
Solar Factors EN410 (2011-04)	
Solar Factor (g)	54%
Shading Coefficient (SC)	0.63
Colour Rendering	
Ra Light Transmittance	97
Ra Outdoor Reflectance	92

Summary of Testing Results for the Glass used in the windows supplied by Paarhammer

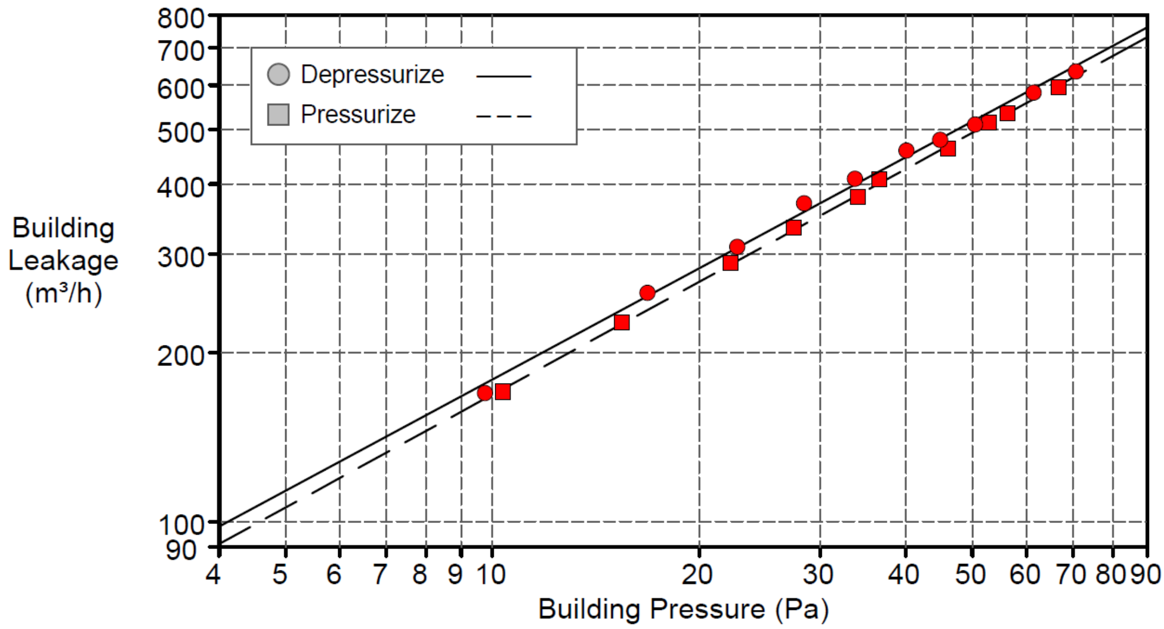
6. AIRTIGHTNESS

An airtightness of 0.81 ACH was achieved at 50 pascals of pressure (the average of 0.83 depressurization and 0.79 pressurisation). The dwelling was constructed to aim for the Passive House standard; as a result, all insulation, thermal bridges and systems values were pushed to meet the standard.

The benefit of aiming for Passive House standard, as explained to the homeowners is that the dwelling actually is stable. The wall buildups and window performance are exceptional. This means that even though the airtightness does not meet the Passive House standard, we are still under the threshold on all other criteria on the Verification sheet.

The house performs well and the two aspects of the design which may have led to a higher leakage are the junction in the roof between the upstairs hall and living room (the stud wall continued beyond the ceiling layer, causing some headache for the builders) and the number of openable windows.

A graph of airtightness results is below.



Graph of Airtightness Results provided by Ryan Parkes

Building Information

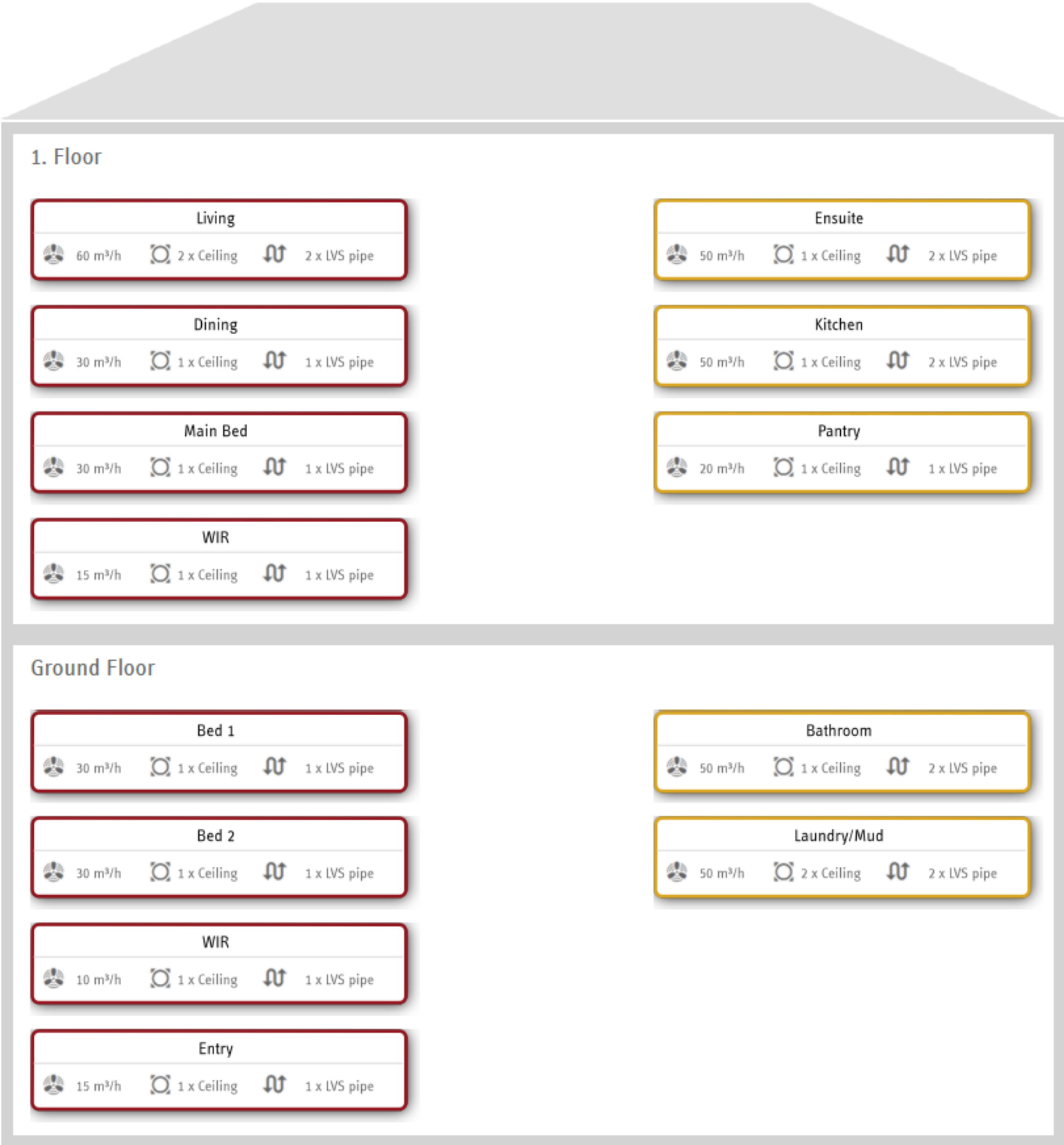
Internal Volume, V (m^3) (according to ISO)	626.82
Net Floor Area, A_F (m^2) (according to ISO)	130
Envelope Area, A_E (m^2) (according to ISO)	644.35
Height (m)	7.6
Uncertainty of Dimensions (%)	0
Year of Construction	2021
Type of Heating	Split system
Type of Air Conditioning	Split system
Type of Ventilation	HRV
Building Wind Exposure	Highly Protected Building
Wind Class	Calm

Building Metrics provided in Airtightness Report provided by Ryan Parkes

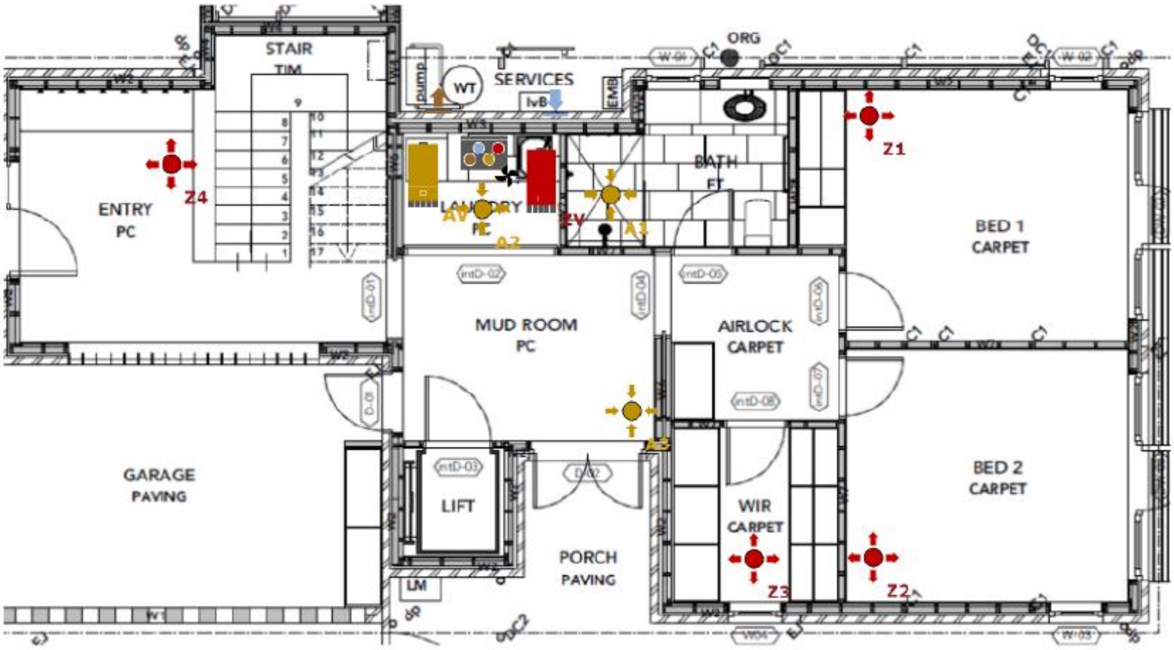
6.1. VENTILATION STRATEGY

Stiebel Eltron were engaged to delineate the ERV strategy. It was intended to have the central unit located in the laundry. Space was tight, so an increased spacing was required between first floor joists to house the manifolds, thus requiring thicker floorboards over the space housing the manifold in the floor sandwich. Below are some diagrams produced by Stiebel Eltron showing the layout and specifications.

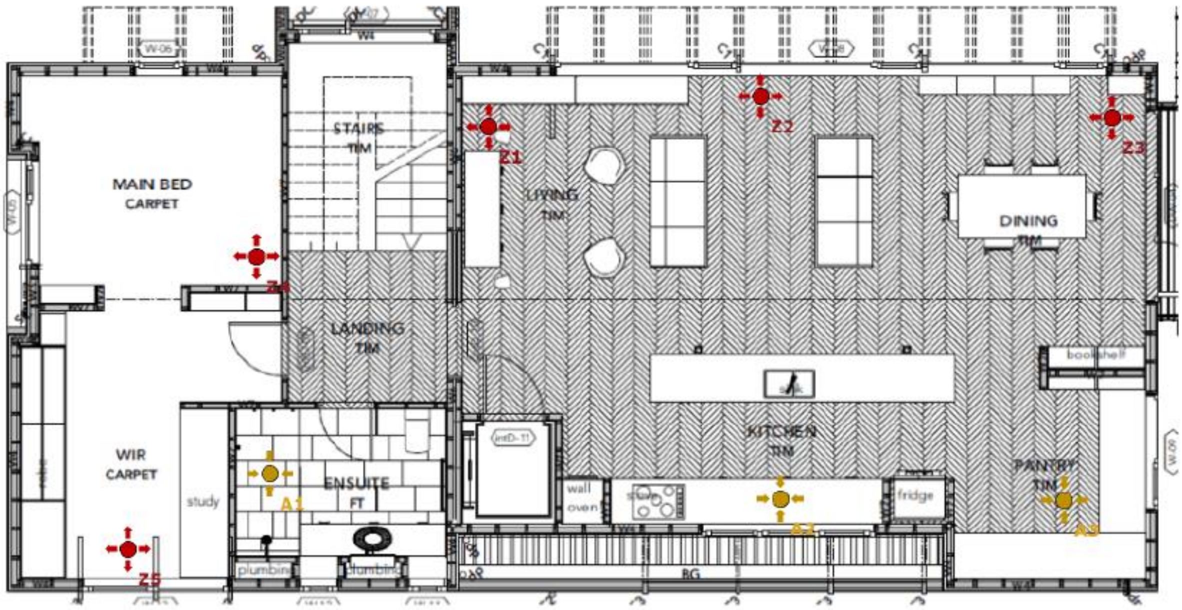
The unit specified is the Steibel Eltron LWZ 170 plus. It was supplied and installed by EnterpriseAir.



Dwelling Floor overview provided by Stiebel Eltron



Ground Floor Plan overview provided by Stiebel Eltron



First Floor Plan overview provided by Stiebel Eltron

Grundriss Legende Ground Floor

	Bezeichnung	Typ	Anschluss Auslass	Luftmenge
Z1	Bed 1	Ceiling outlet	1 x LVS pipe	30 m³/h
Z2	Bed 2	Ceiling outlet	1 x LVS pipe	30 m³/h
Z3	WIR	Ceiling outlet	1 x LVS pipe	10 m³/h
Z4	Entry	Ceiling outlet	1 x LVS pipe	15 m³/h
A1	Bathroom	Ceiling outlet	2 x LVS pipe	50 m³/h
A2	Laundry/Mud	Ceiling outlet	1 x LVS pipe	25 m³/h
A3	Laundry/Mud	Ceiling outlet	1 x LVS pipe	25 m³/h
	Lüftungsgerät	LWZ 170		160 m³/h
ZV	VTS Verteiler	Zuluft	9 x LVS pipe	220 m³/h
AV	VTS Verteiler	Abluft	9 x LVS pipe	220 m³/h

Grundriss Legende 1. Floor

	Bezeichnung	Typ	Anschluss Auslass	Luftmenge
Z1	Living	Ceiling outlet	1 x LVS pipe	30 m³/h
Z2	Living	Ceiling outlet	1 x LVS pipe	30 m³/h
Z3	Dining	Ceiling outlet	1 x LVS pipe	30 m³/h
Z4	Main Bed	Ceiling outlet	1 x LVS pipe	30 m³/h
Z5	WIR	Ceiling outlet	1 x LVS pipe	15 m³/h
A1	Ensuite	Ceiling outlet	2 x LVS pipe	50 m³/h
A2	Kitchen	Ceiling outlet	2 x LVS pipe	50 m³/h
A3	Pantry	Ceiling outlet	1 x LVS pipe	20 m³/h

Duct and Equipment Legend provided by Stiebel Eltron

The Steibel Eltron LWZ 170 Plus: Heat Recovery efficiency is 86%, electrical efficiency is 0.26W/m².

6.2. AIRTIGHTNESS TESTING

Airtightness testing was conducted by ATTMA accredited tester Ryan Parkes. It was the wish of the project team that a test be conducted before lining the frame with plasterboard. Another test was also conducted after the builder had a chance to rectify some leakage issues.

A final test was also conducted producing the results disclosed previously. The same door was used for all tests with the intent of testing in similar conditions.

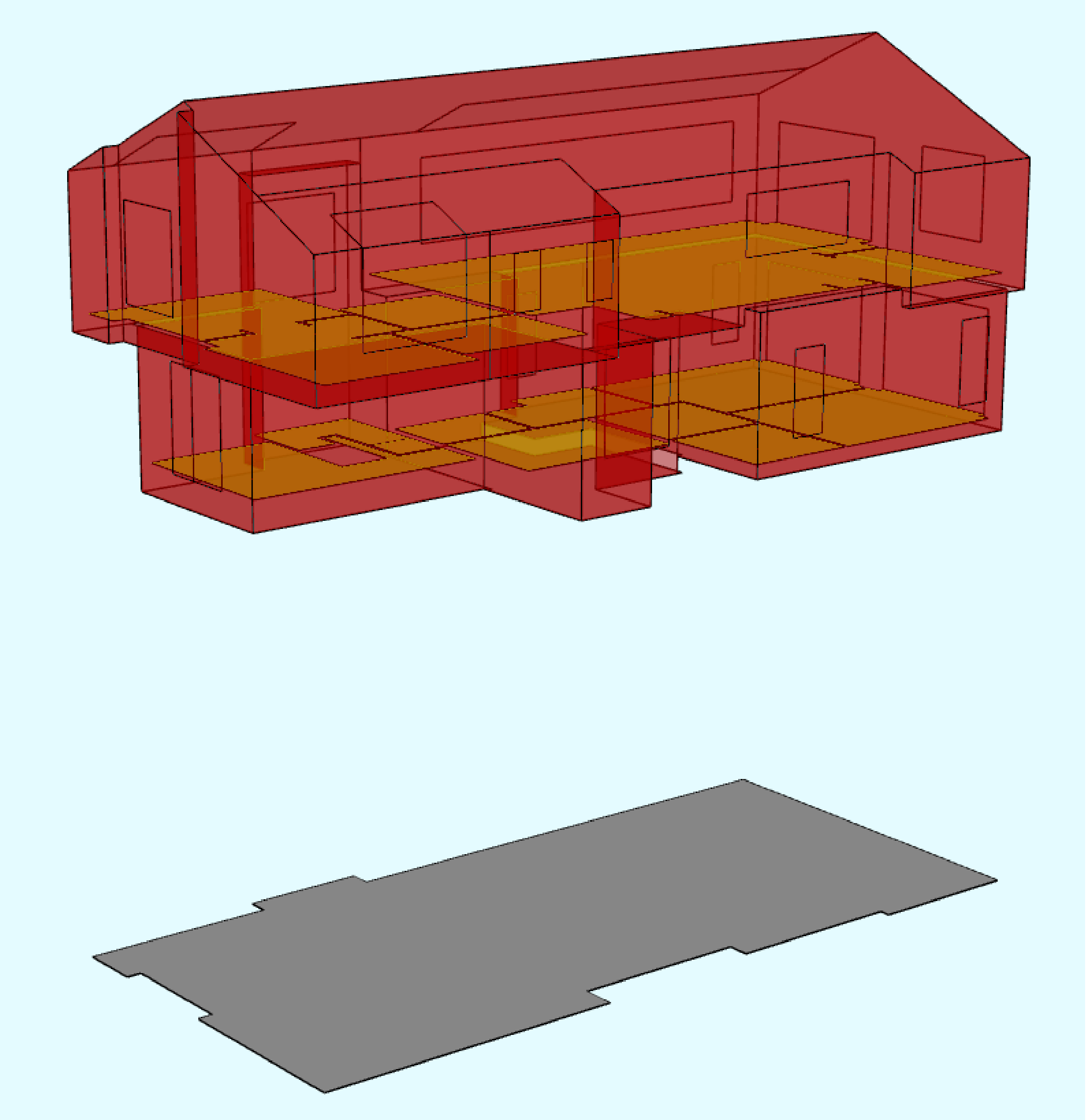
A test conducted, pre-plaster from the North-East bedroom of the Ground Floor

6.3. AIRTIGHTNESS MEMBRANE

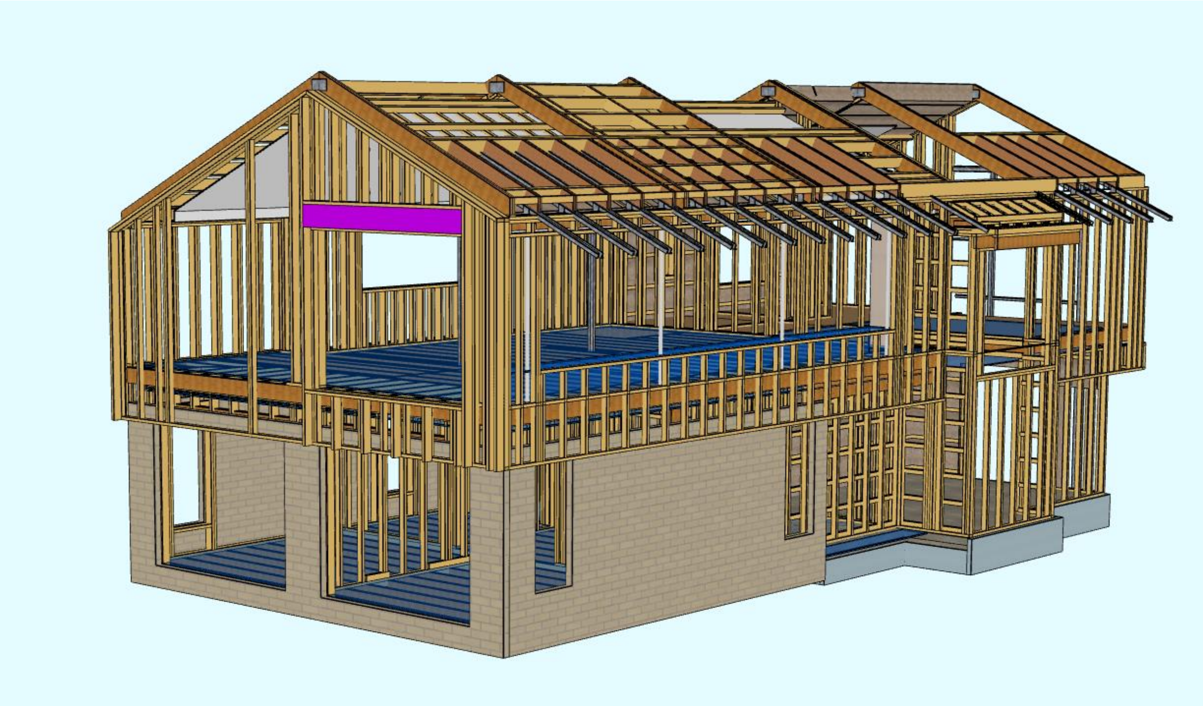
The membrane used was supplied by Proctor Group Australia and is the ProctorPassive Smartvap 100. This membrane was used on all external walls, the ceiling of the first floor and the floor of the first floor, connecting the external walls over the floor overhang as the ground floor external walls are inset from the first floor external walls.

7. DETAIL MODELLING

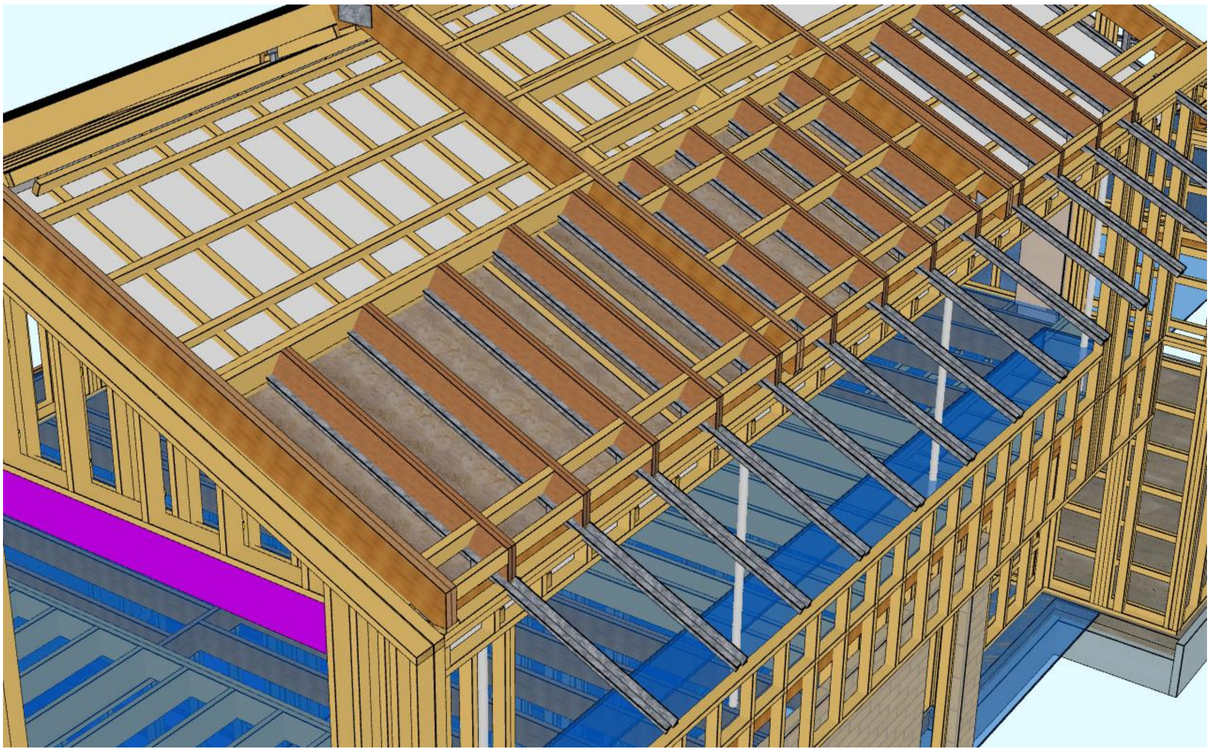
As this project was calculated through the PHPP at a very late stage I also looked into the relationship between Passive House elements and structural elements to ensure the thermal bridge calculations were effective and accurate. The images below show some of the issues which were solved through 3D modelling and integration of extra layers of BIM using Cadwork software using my workshop detailing experience.



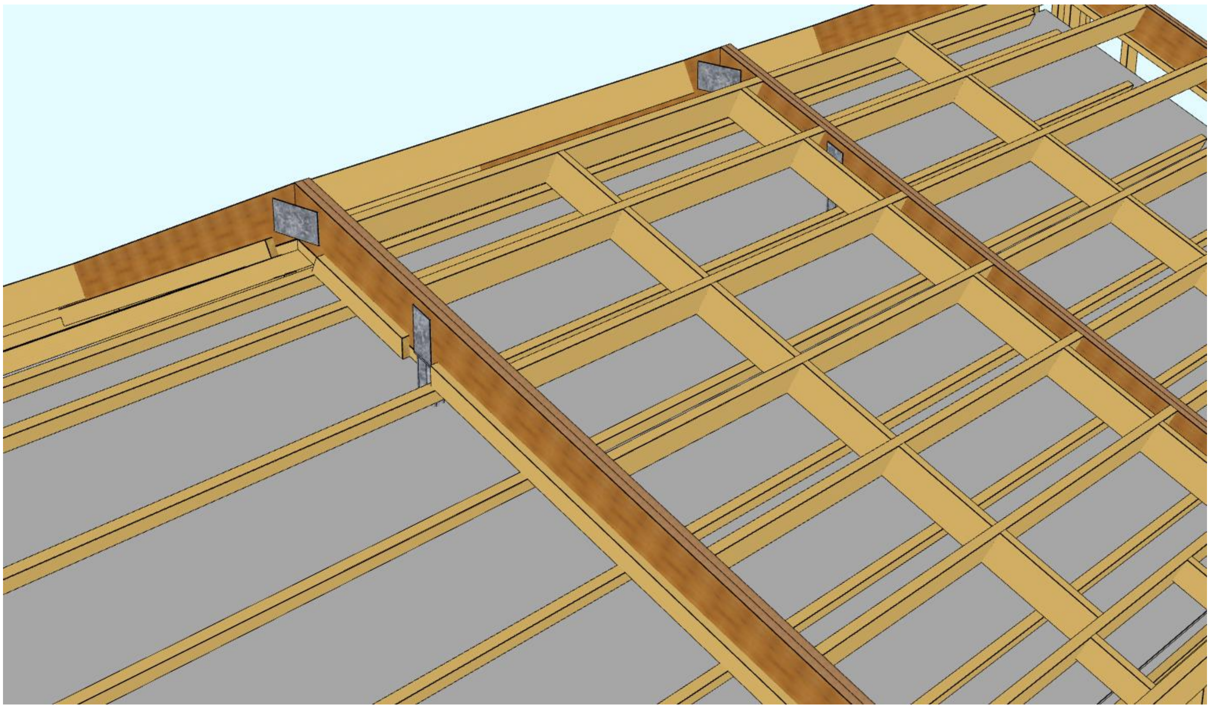
Areas as inputted into the PHPP



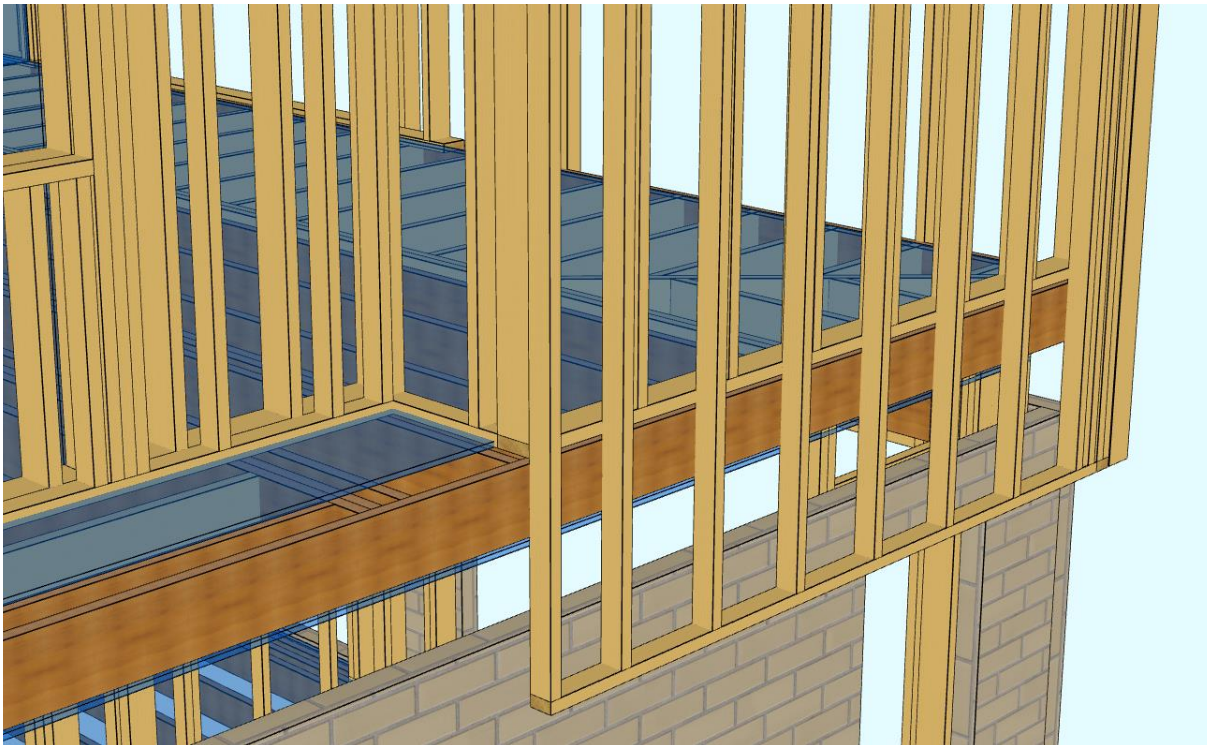
Structural Detailing overview to work out relationship between members and membranes



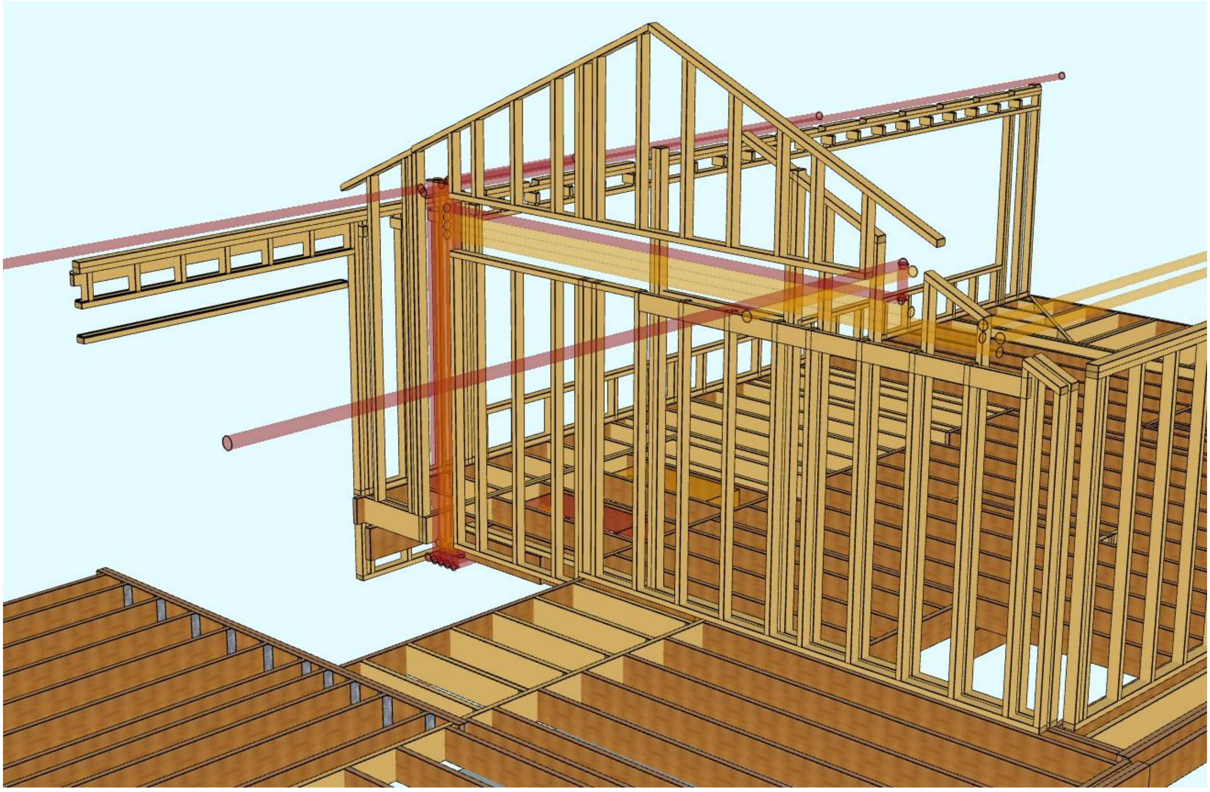
Close-Up of Northern shading outriggers



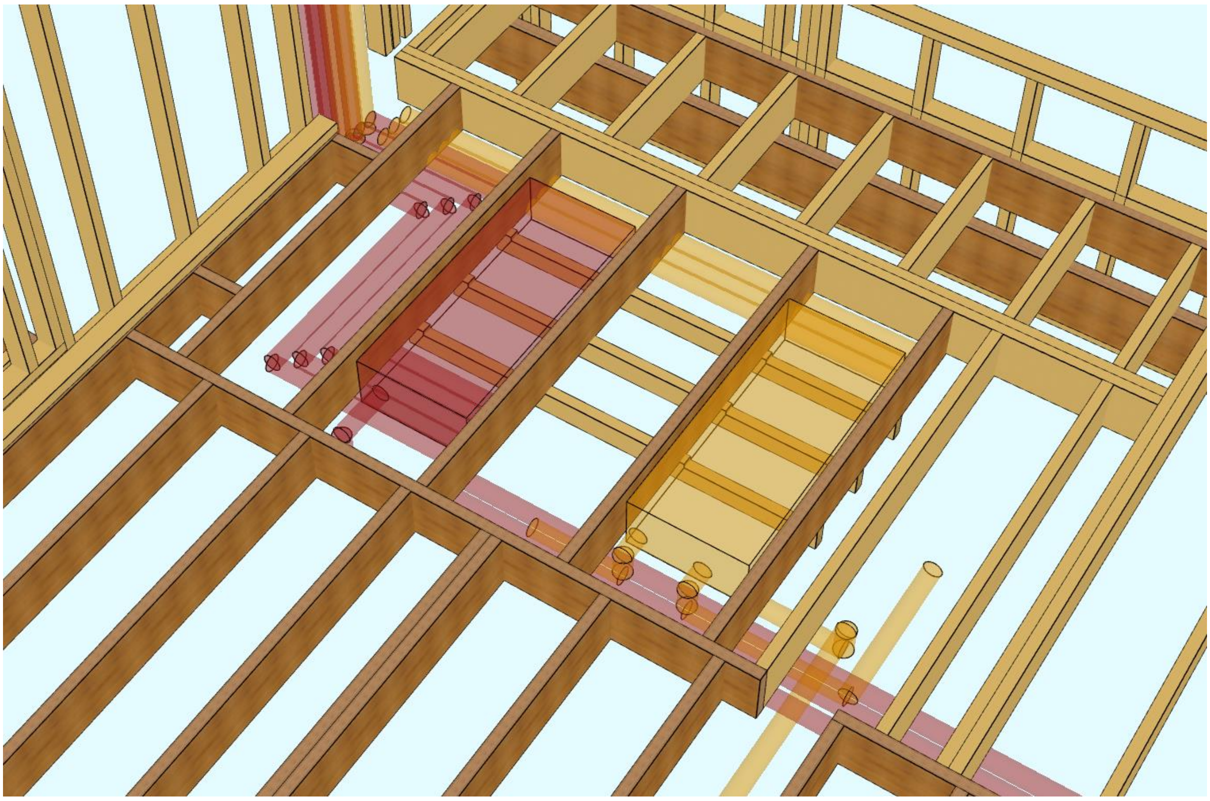
Close-Up of relationship between purlins and ceiling battens



Flanking of 90mm Stud wall on outside of 140mm structural layer



3D Model of ERV Ductwork



Calculation of spacing for manifolds above laundry ceiling

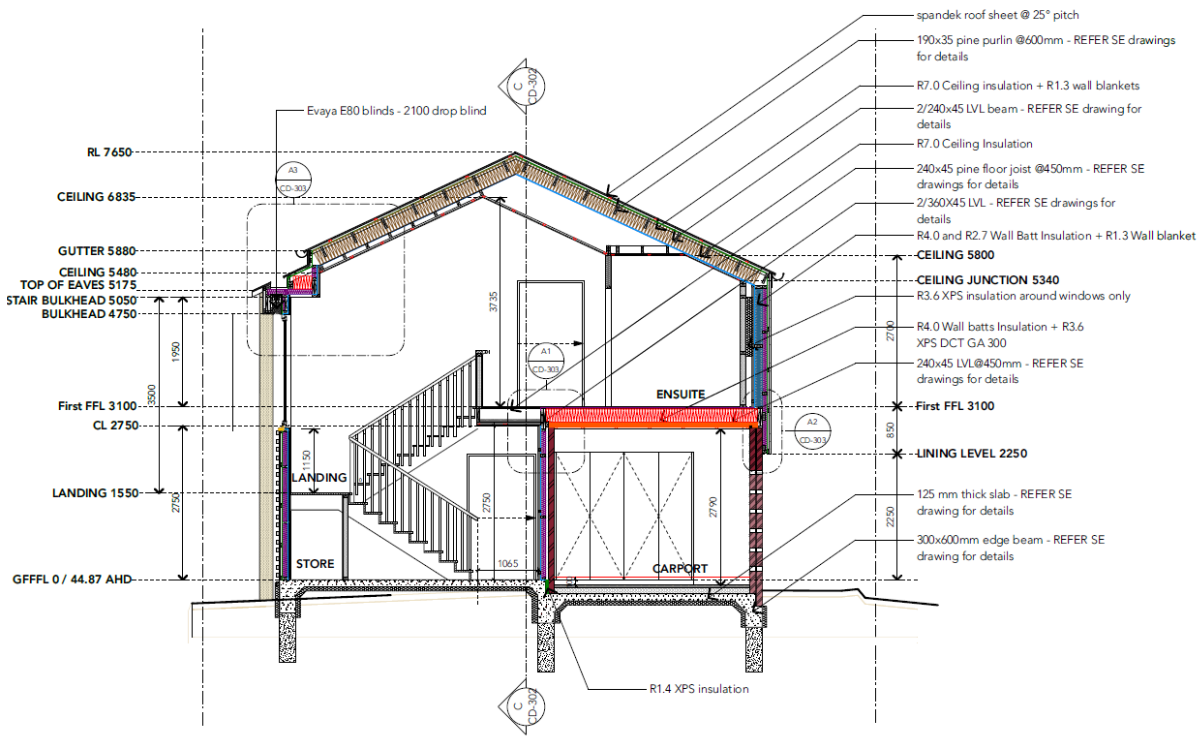
8. ARCHITECTURAL DETAILING

Details were provided by DiMase Architects to better communicate the requirements of the builder to the builder. This detailing assisted also in the process of communicating the requirements to the architect so that the whole team was on board and understood what was to be installed to meet the standard.

8.1. SECTION THROUGH STAIRWELL

This section demonstrated the different types of thermal envelope components that formed the thermal envelope. The number of different components is a direct result of needing to achieve efficiency in fairly 'locked-in' thermal envelope along with cost-saving measures to ensure thresholds are met without increasing the performance of all walls, all roofs and/or all floors.

This section also communicates the location and intent with the false raked ceiling.

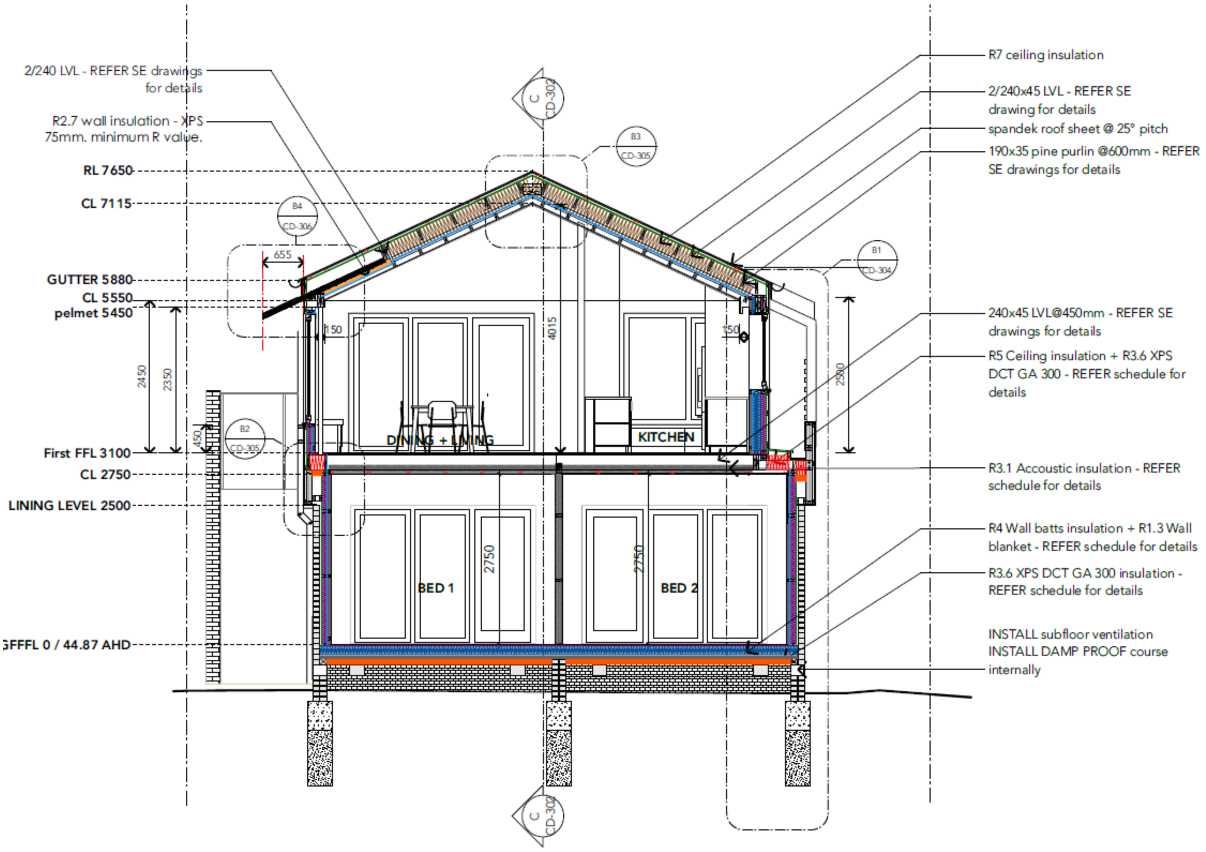


Sectional Drawing through the Stairwell provided by DiMase Architects

8.2. SECTION THROUGH BEDROOMS AND KITCHEN

This section shows two particular parts of the thermal envelope which required some thought in the way they were thermally modelled, one being the Northern shading device and the other being the small exposed ceiling at the Southern Bedroom and Walk-In-Robe, just under the kitchen window.

At one point in the process XPS was specified to be installed under the floor slab. As this was not practical and a reduction of losses was able to be confirmed, it was one of the first layers of insulation to be removed from the specification.

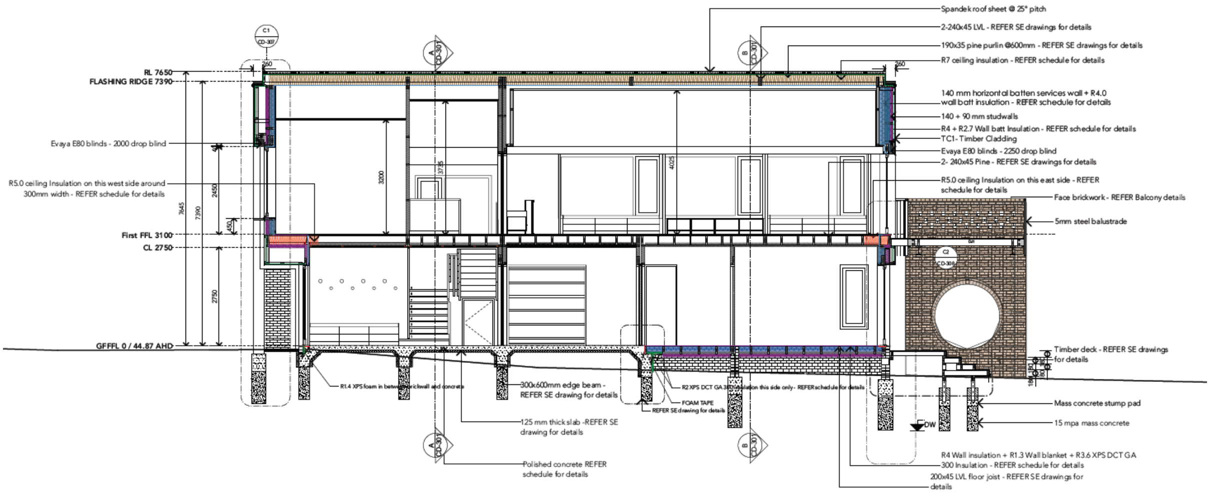


Sectional Drawing through the Bedrooms and Kitchen provided by DiMase Architects

8.3. LONGITUDINAL SECTION

Drawn in line with the Roof Ridge looking North, this section clearly shows the placement of insulation on the building envelope. One important aspect shown here is the inclusion of extra insulation placed in the floor sandwich to the East. We provided advice to do this to mitigate the effect of thermal bridging from a 140mm stud wall junction with the floor sandwich to a double stud (140mm + 90mm) wall on the upper floor.

This detail has a similar effect to underslab perimeter insulation, whereby heat impacts the building element in curved shapes, so insulation deeper in the building element is not as effective as insulation at the extremities. The detail also allowed for a nice transition between the floor overhang and the Eastern edge of the floor (which was not overhanging). Ground Floor Eastern windows received a benefit of shade from the deck which was thermally separated from the thermal envelope.

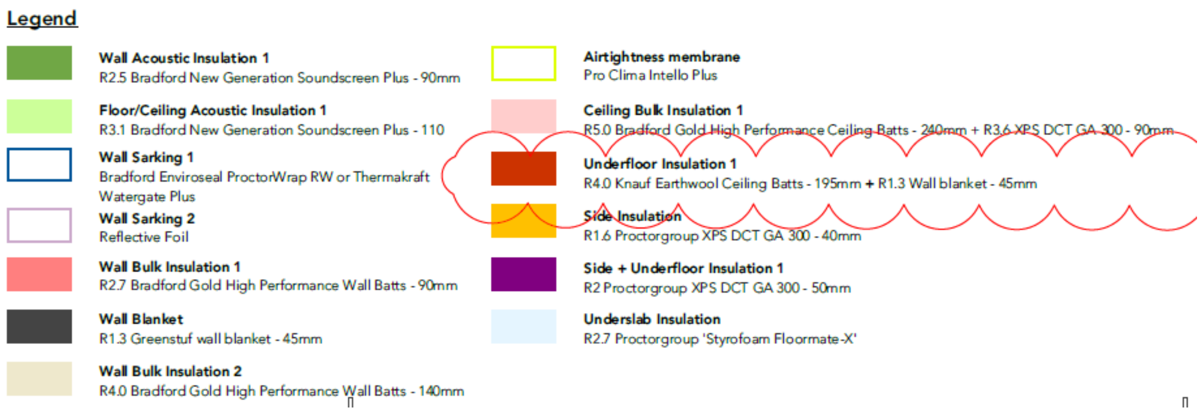


Longitudinal Sectional Drawing provided by DiMase Architects

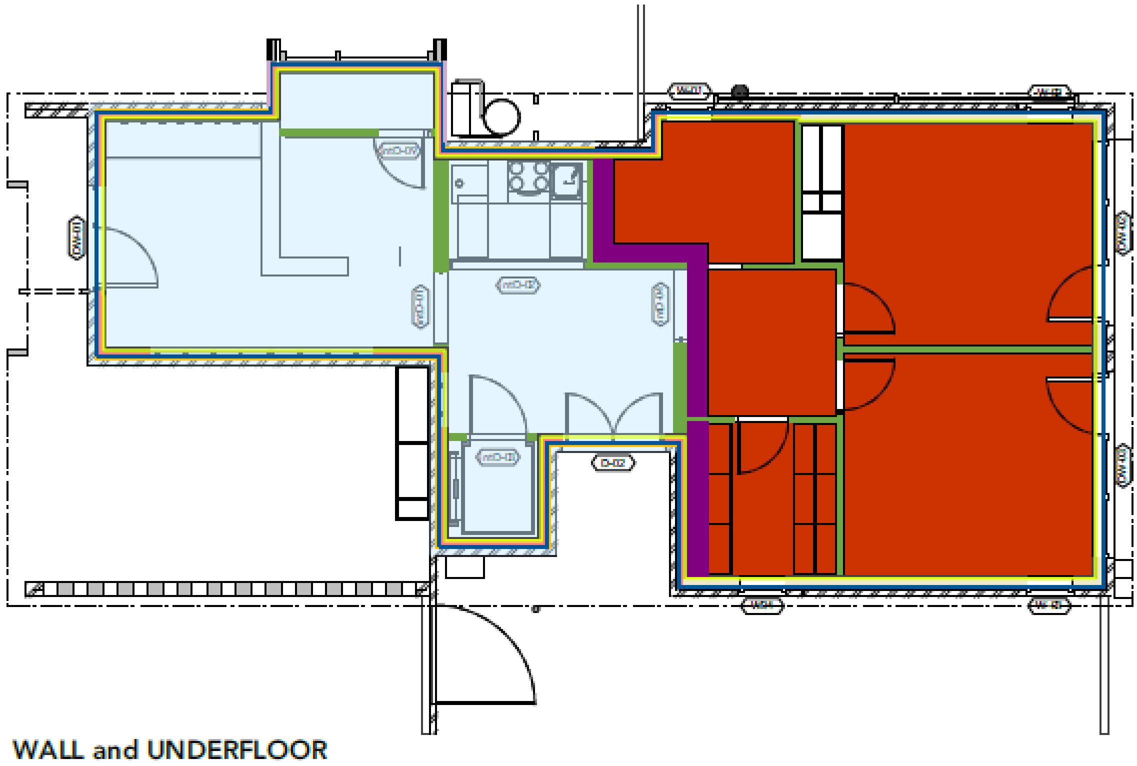
8.4. INSULATION DIAGRAMS

Over the next couple of pages are included some insulation diagrams showing the varying types of insulation specified in the dwelling to ensure that it meets the Passive House standard. Because the walls were varying at different points of the thermal envelope, all parties had to be clear about what was to be installed where.

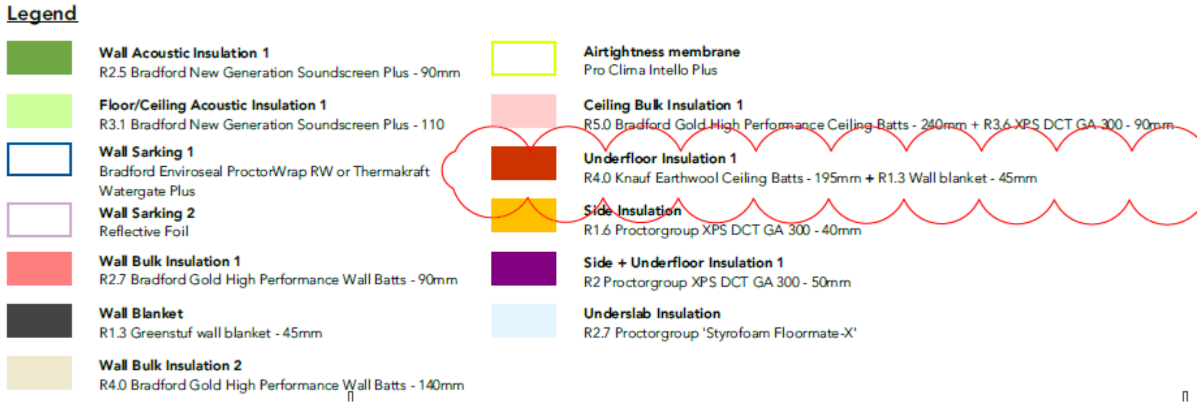
Working closely with Niea from DiMase Architects, a clear summary was created for the benefit of the builder and discussions could be had about how practical the installation of insulation was. It was from this discussion that a list of prioritised insulations reductions were created to be triggered as we benefitted from conservative estimates of thermal bridging.



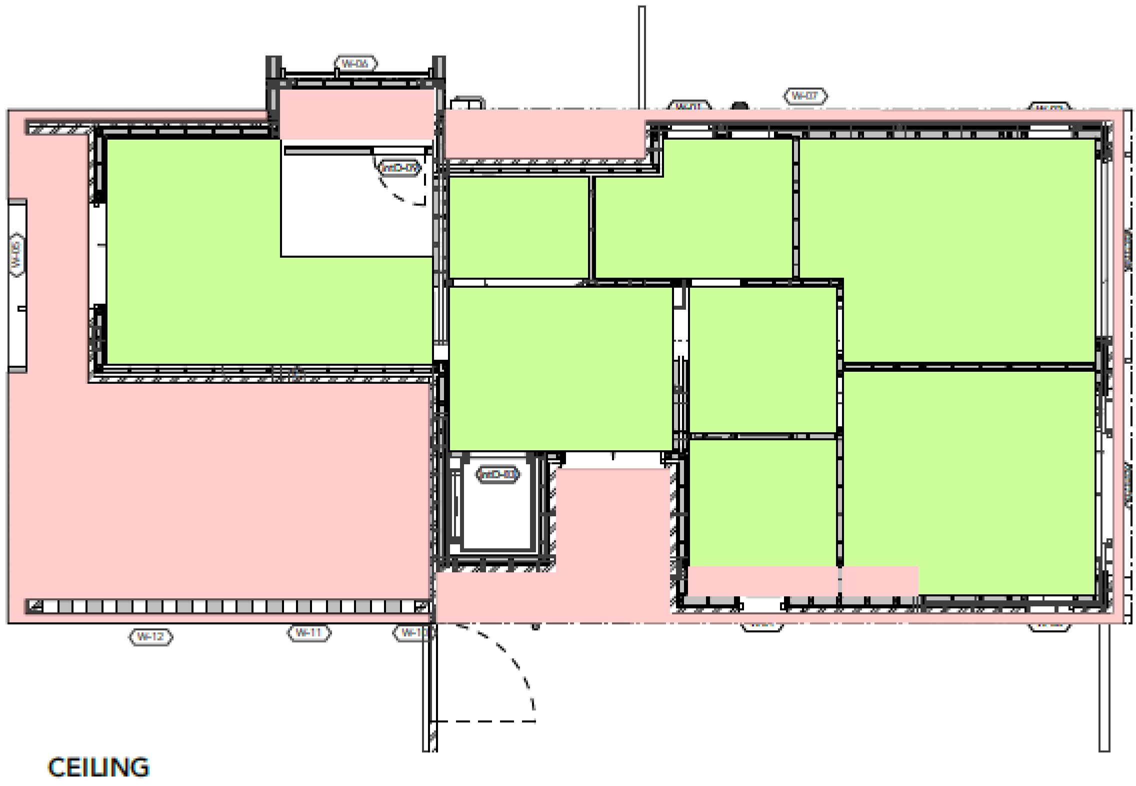
Ground Floor Insulation Legend provided by DiMase Architects



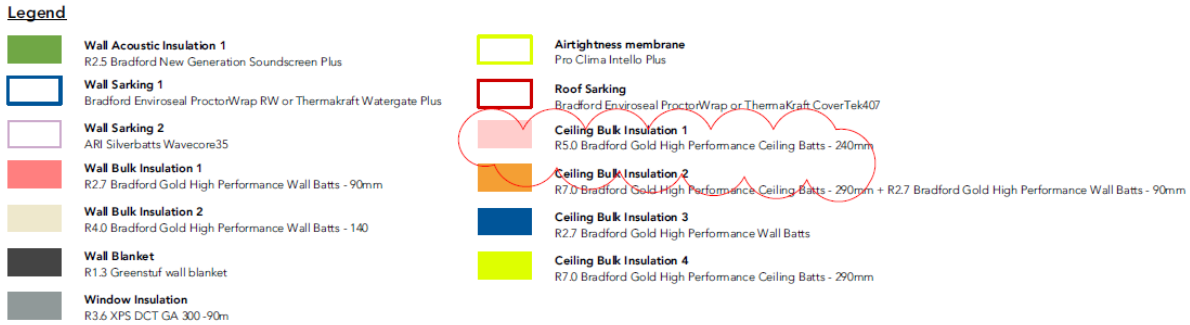
Ground Floor Under Floor and Wall Insulation Diagram provided by DiMase Architects



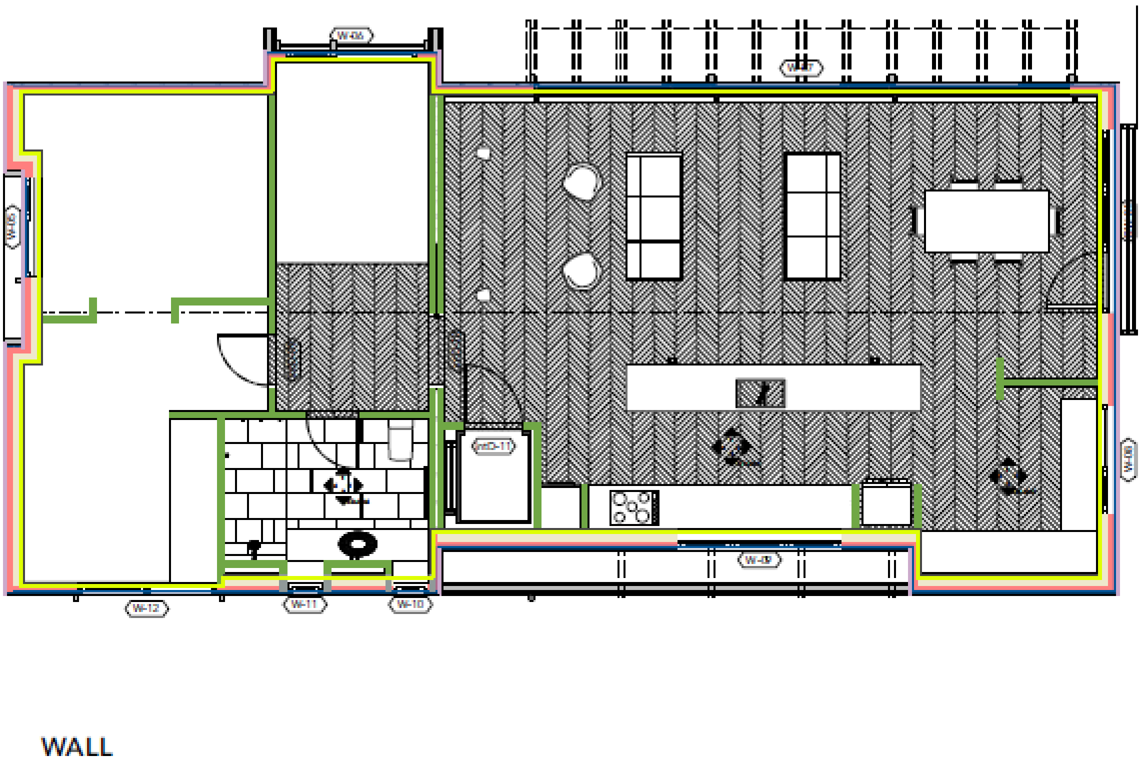
Ground Floor Insulation Legend provided by DiMase Architects



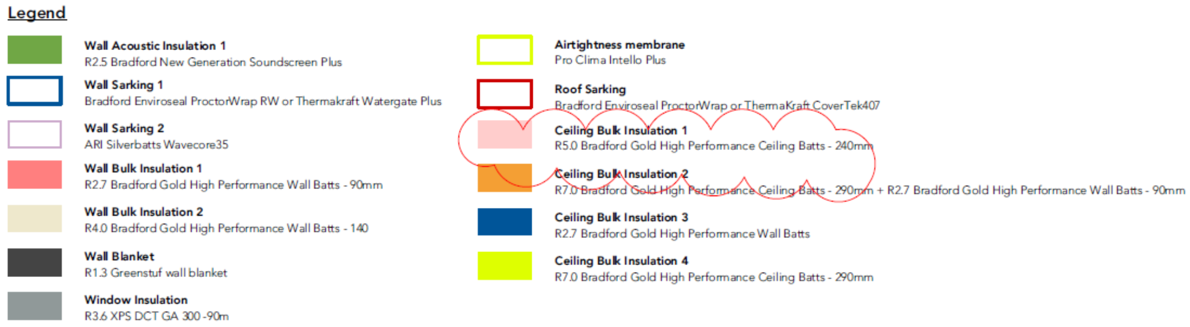
Ground Floor Ceiling Insulation Diagram provided by DiMase Architects



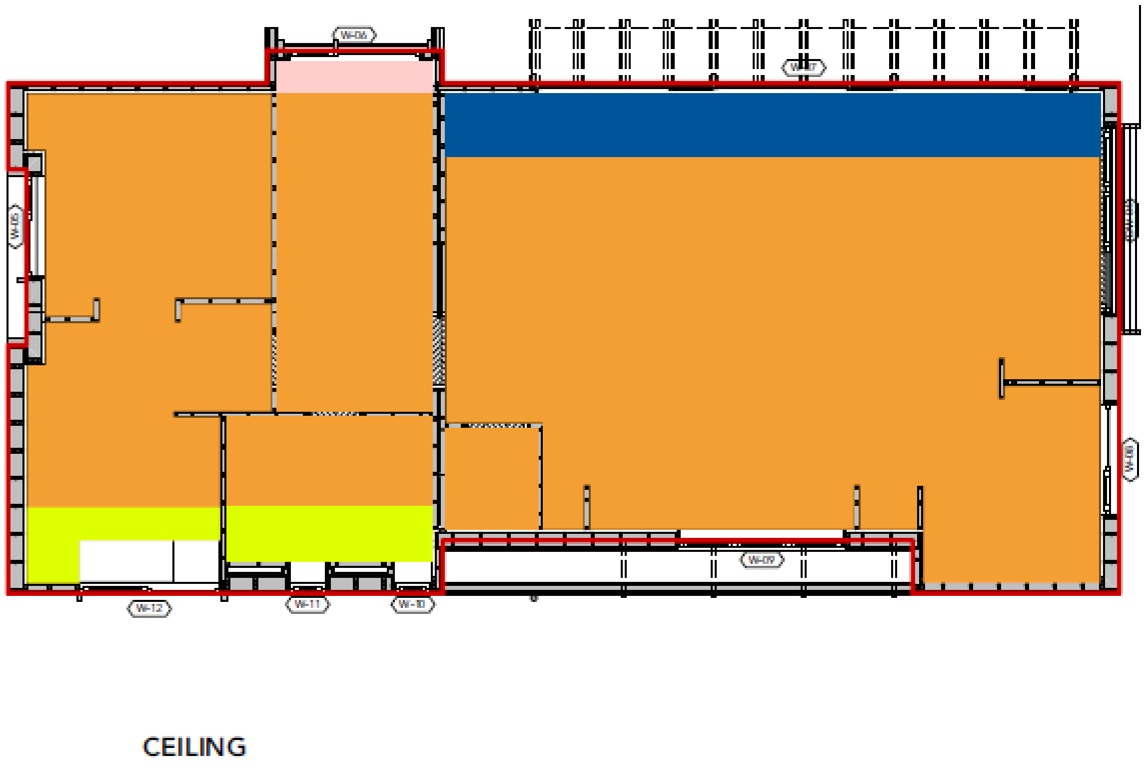
First Floor Insulation Legend provided by DiMase Architects



First Floor Wall Insulation Diagram provided by DiMase Architects



First Floor Insulation Legend provided by DiMase Architects



First Floor Ceiling Insulation Diagram provided by DiMase Architects

More information and architectural photos can be found at the DiMase Architects website, available at: https://www.dimasearchitects.com.au/projects/park-house-northcote. A small selection of photos which we have taken are shown from the next page.

If you have any questions about this Passive House project documentation report, please reach out to me at alex@buildingphysics.au or on +61 (0)406 376 341.

South Western corner of the house, showing the connection to Whalley Street

Northern Façade of the dwelling, showing connection to trees in 'All Nations Park'

Western Façade of the dwelling, showing integration of carport to form of dwelling

North-East corner of the dwelling, showing shading provided by first floor deck and trees