

PROJECT DOCUMENTATION



1.0 ABSTRACT / ZUSAMMENFASSUNG



Detached single family dwelling in Radstock, UK

1.1 BUILDING DATA / GEBÄUDEDATEN

Year of construction/ Baujahr	2018	Space heating / Heizwärmebedarf	13.9 kWh/(m ² a)
U-value external wall/ U-Wert Außenwand	0.084 W/(m ² K)		
U-value floor slab/ U-Wert Bodenplatte	0.105 W/(m ² K)	Primary Energy/ Primärenergie	104 kWh/(m ² a)
U-value roof/ U-Wert Dach	0.076 W/(m ² K)	Generation of renewable energy / Erzeugung erneuerbare Energie	20 kWh/(m ² a)
U-value window/ U-Wert Fenster	0.865 W/(m ² K)	Non-renewable Primary Energy (PE) / Nicht erneuerbare Primärenergie (PE)	73 kWh/(m ² a)
Heat recovery/ Wärmerückgewinnung	90.6%	Pressure test n50 / Drucktest n50	0.28/h
Special features/ Besonderheiten	PV array, SunAmp heat battery		

1.2 BRIEF DESCRIPTION

Deasil is a self-build house to the south of Bath; constructed, managed and now lived-in by the architect and his family. Sited in a conservation area in the former Somerset coal fields, it required pitched roof forms and a low building height, leading to a challenging form heat-loss factor.

The Cross-Laminated Timber (CLT) frame, exposed internally, was erected in just 5 days and allowed a lightweight raft foundation to be used. Externally the building is clad in Brimstone Ash, a heat-treated timber, in a vertical board and batten arrangement redolent of rural barn buildings.

An integrated rooftop PV array & phase-change storage satisfies a substantial fraction of the annual domestic hot water demand.

1.3 RESPONSIBLE PROJECT PARTICIPANTS / VERANTWORTLICHE PROJEKTBETEILIGTE

Architect/ Entwurfsverfasser	Tom Fowlie tom.fowlie@yahoo.com
Building systems/ Haustechnik	Green Building Store (MVHR) www.greenbuildingstore.co.uk
Structural engineering/ Baustatik Building	Ramboll UK uk.ramboll.com
Craftspersons involved/ Handwerker	Coombes Carpentry, Earthwise Construction, EcoMirage (PV) G-frame Structures (CLT)
Certifying body/ Zertifizierungsstelle	WARM: low energy building practice www.peterwarm.co.uk
Certification ID/ Zertifizierungs ID	Project ID (ID 6329)
Author of project documentation / Verfasser der Gebäude-Dokumentation	Tom Fowlie tom.fowlie@yahoo.com
Date	02.06.20

2.0 VIEWS OF THE PASSIVHAUS



South. The main elevation of the house faces mature trees, with glazing sized for views and adequate daylight.



East. This elevation faces the road with windows into the mezzanine and 3rd bedroom.



North. Rear elevation with minimal glazing. MVHR intake & exhaust terminals visible.

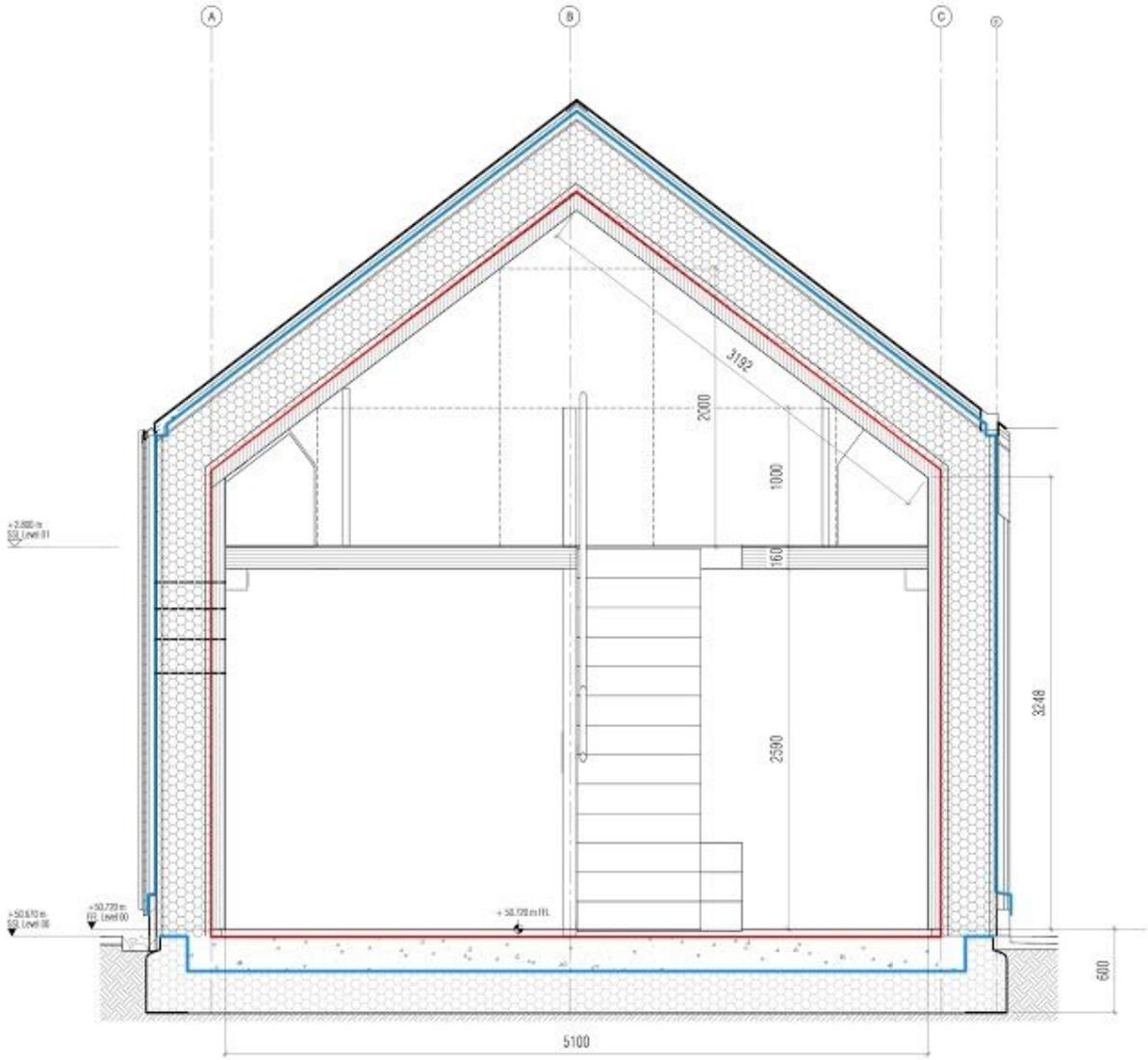


West. These elevations face open fields, with picture windows to the main bedroom and the living area.



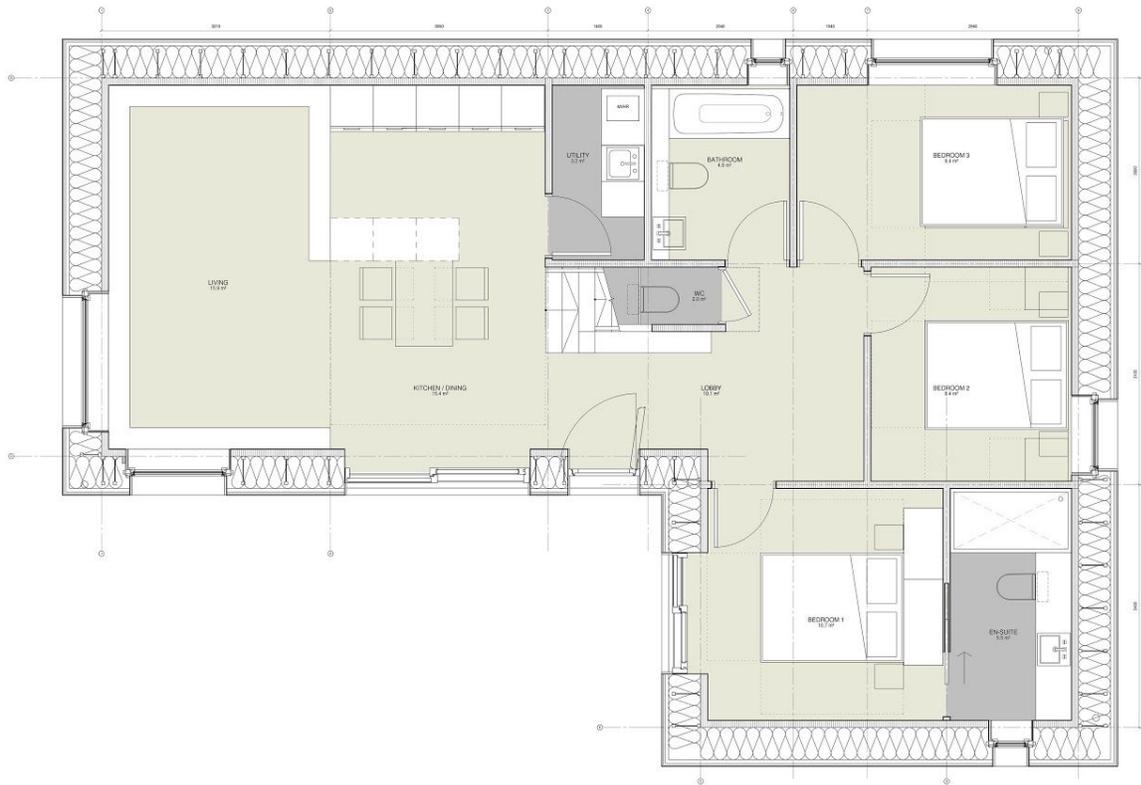
Interior. View from the dining area towards the main living space and the view looking West.

3.0 TYPICAL SECTION

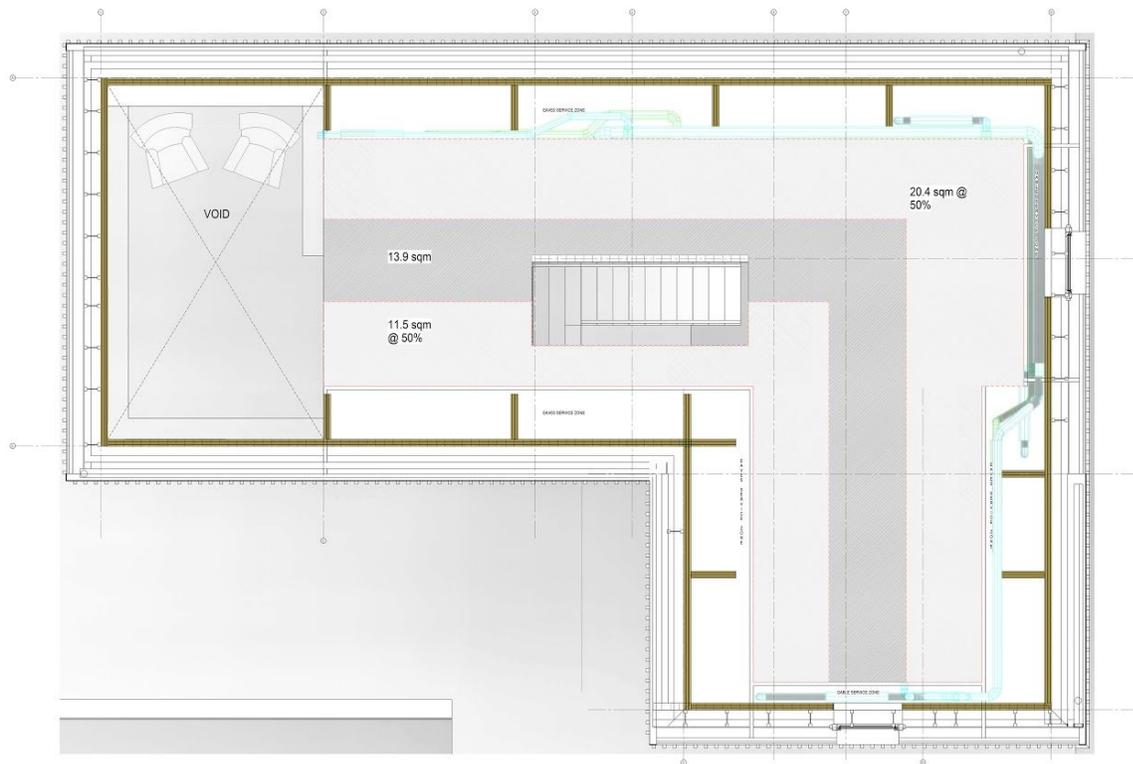


Typical Cross-Section. Indicating simple, continuous thermal envelope strategy. Blue line represents the weather barrier, the red line is airtightness. Dashed lines on the left (North) indicate penetrations for MVHR.

4.0 FLOOR PLANS



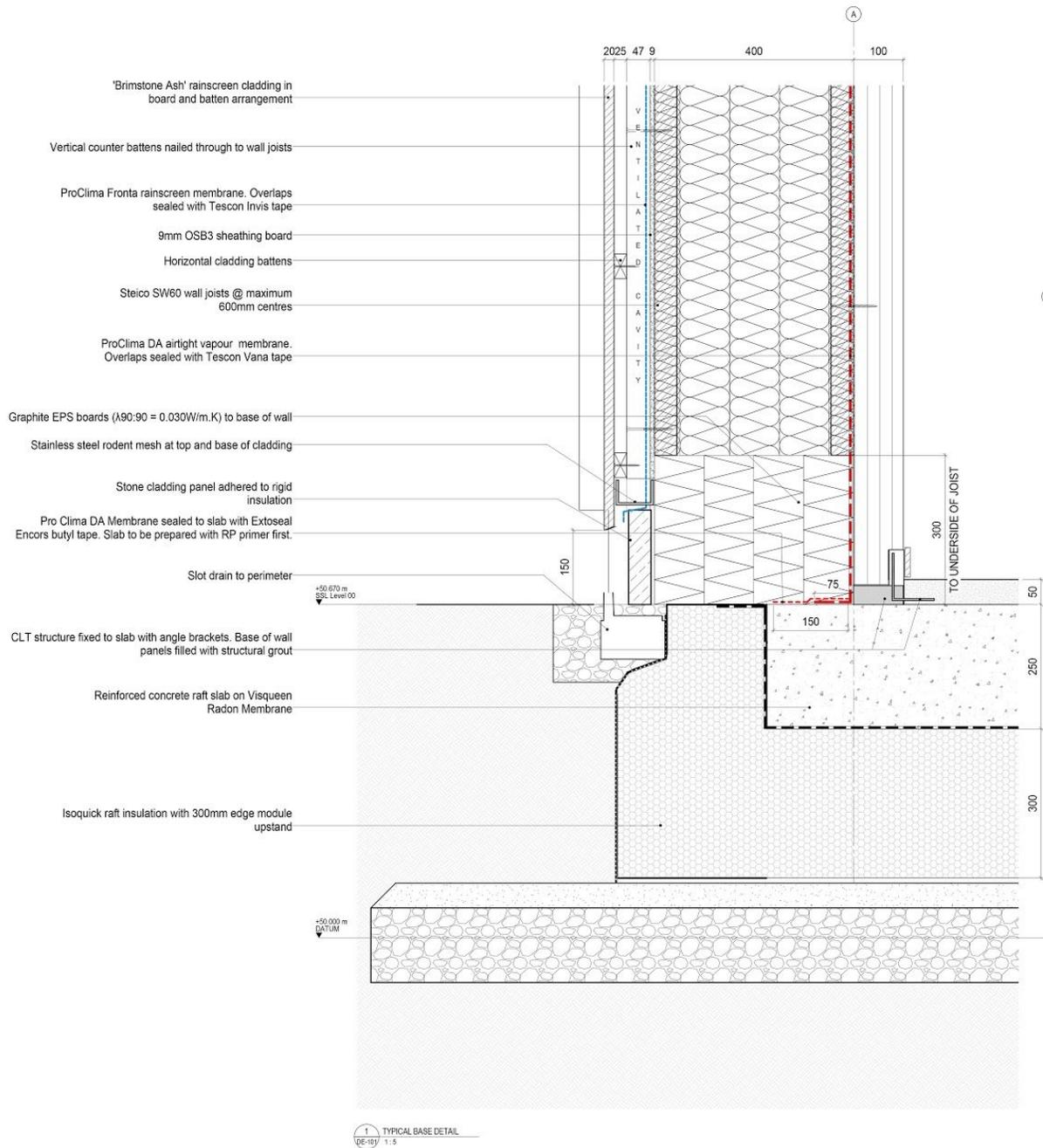
Ground Floor Plan.



First Floor Plan.

5.0 CONSTRUCTION DETAILS

5.1 GROUND FLOOR SLAB



The Ground Floor slab is constructed from a raft of reinforced concrete on an Isoquick insulation/formwork system with upstands (0.033 λ W/(mK)). At thresholds, lengths of dense Compacfoam insulation (0.046 λ W/(mK)) were laid with stainless steel threaded bar cast into the slab edge to reduce thermal bridging and provide adequate compressive strength.



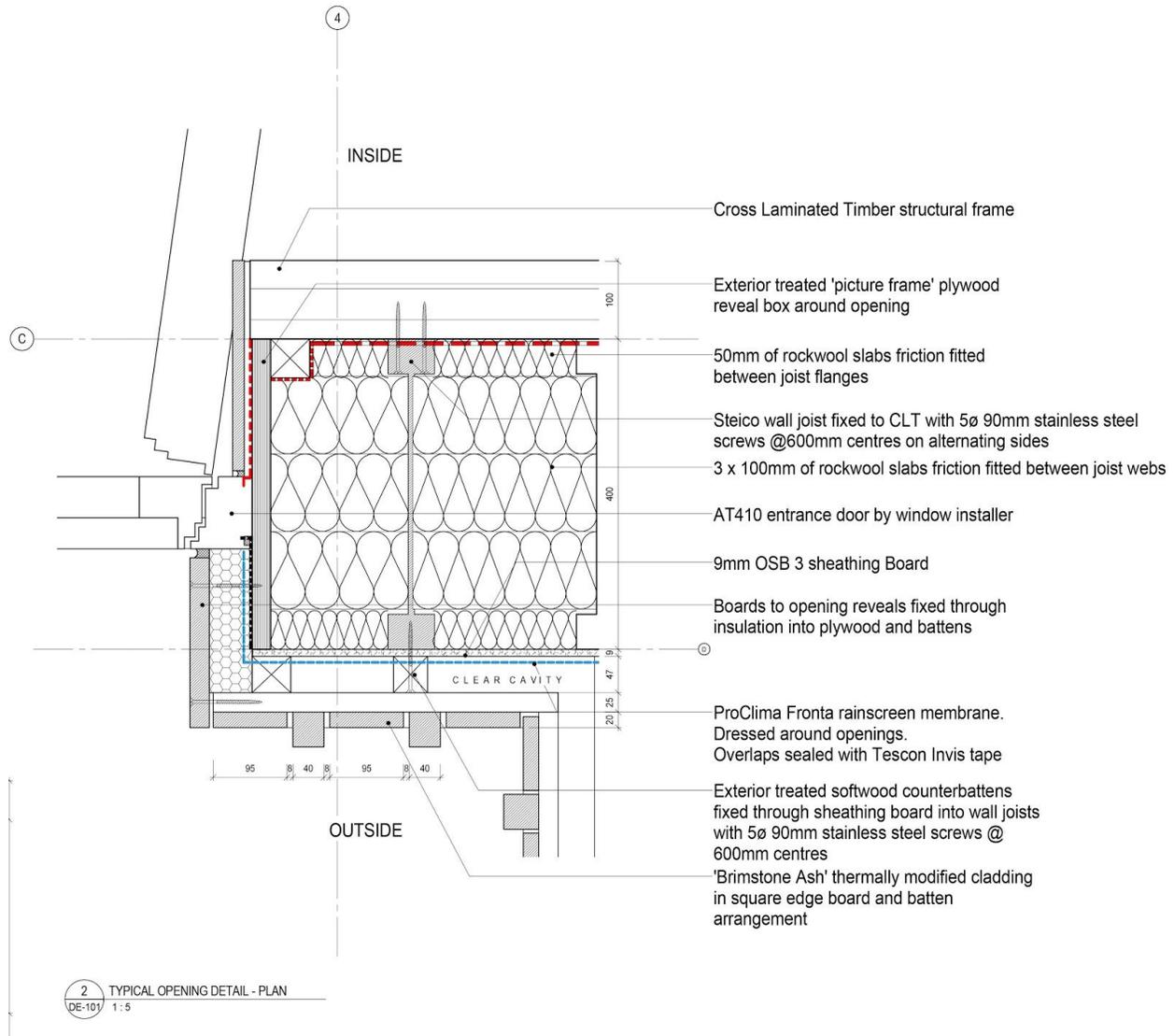
FLOOR DATA

	λ W/(mK)	mm
Solid Timber	0.160	25
Cement Screed	1.150	45
Concrete Slab	2.300	250
Insulation	0.033	300

U-VALUE

0.105 W/m²K

5.2 WALL CONSTRUCTION



The external walls are constructed from a structural frame of Cross-Laminated Timber, fire-treated and exposed on the inside face and wrapped in ProClima DA airtight vapour check on the outside face. This is overlaid with mineral wool insulation slabs fitted between a 'Larsen Truss' system of engineered timber joists that support an outer sheathing board carrying the breather membrane.

The junction above indicates a typical opening (door/window) supported off a plywood box that cantilevers from the main frame (see section 5.4). The Larsen trusses above/below support these ply boxes and, aside from the openings and the trusses themselves, the insulation layer is continuous both around all corners of the building in plan and up and over the roof.

A sub-grid of battens and counterbattens carries the ventilated timber rainscreen. The mineral wool and trusses stop around 300mm above the external ground level and the remaining insulation is graphite EPS slabs to form a continuous thermal line from the isoquick upstands around the slab.

WALL DATA

	λ W/(mK)	mm
CLT	0.130	100
Vapour Barrier	0.500	0
Rockwool (with timber fraction)	0.034	400
OSB	0.130	12

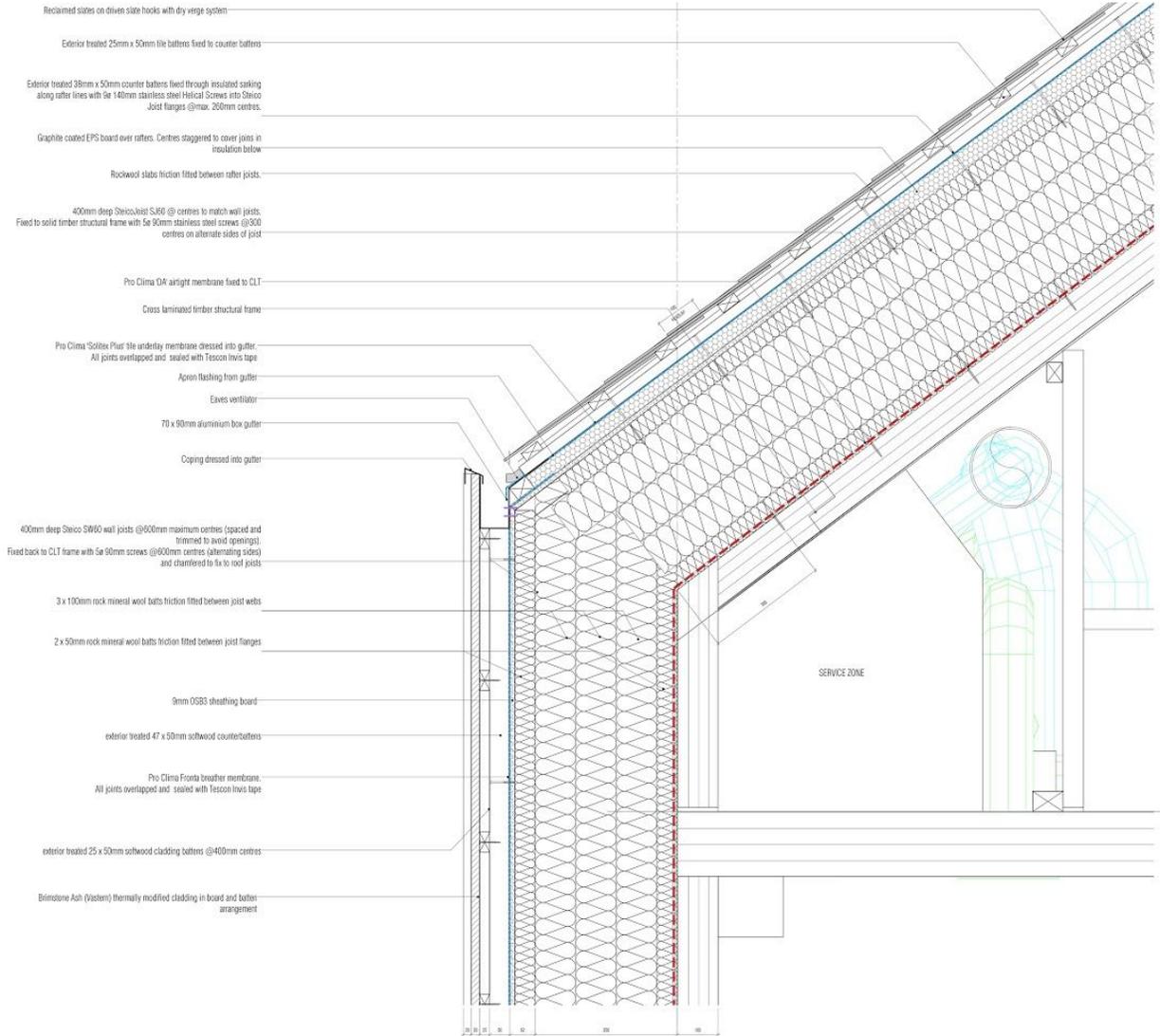
U-VALUE

0.084 W/m²K



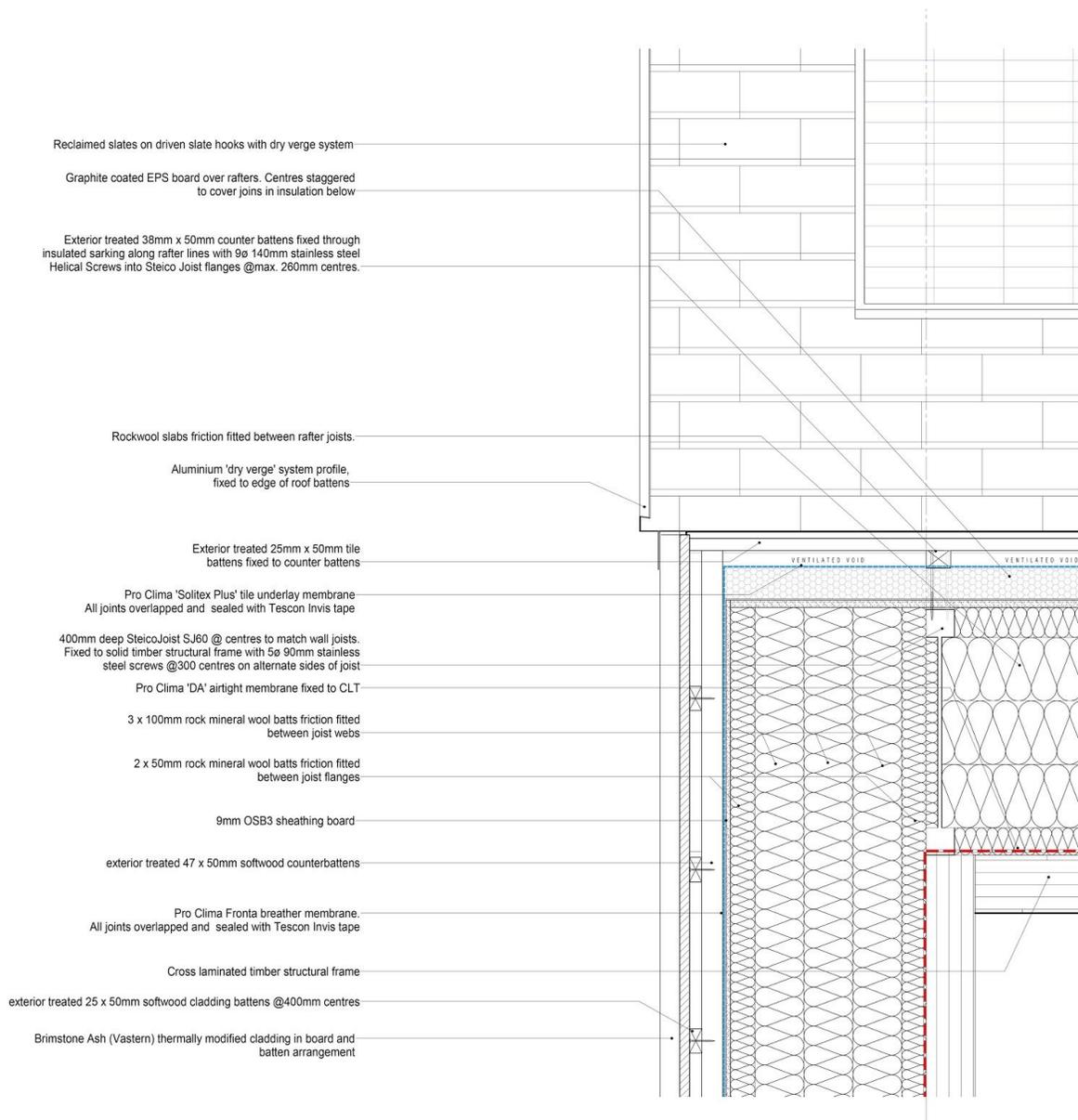
Construction photo showing the 'Larsen Trusses' with mineral wool infill.

5.3 ROOF CONSTRUCTION



EAVES DETAIL

Like the external walls, the roof is constructed from a structural frame of Cross-Laminated Timber. The 'Larsen Trusses' wrap up and over the ridge and the mineral wool fill continues in the same arrangement. Where the construction differs is an outer layer of 50mm graphite EPS slabs laid over the sheathing board to provide extra insulation, with the roof battens fastened using helical screws into the outer chord of the engineered joists. Ventilated slates and a roofing membrane complete the enclosure.



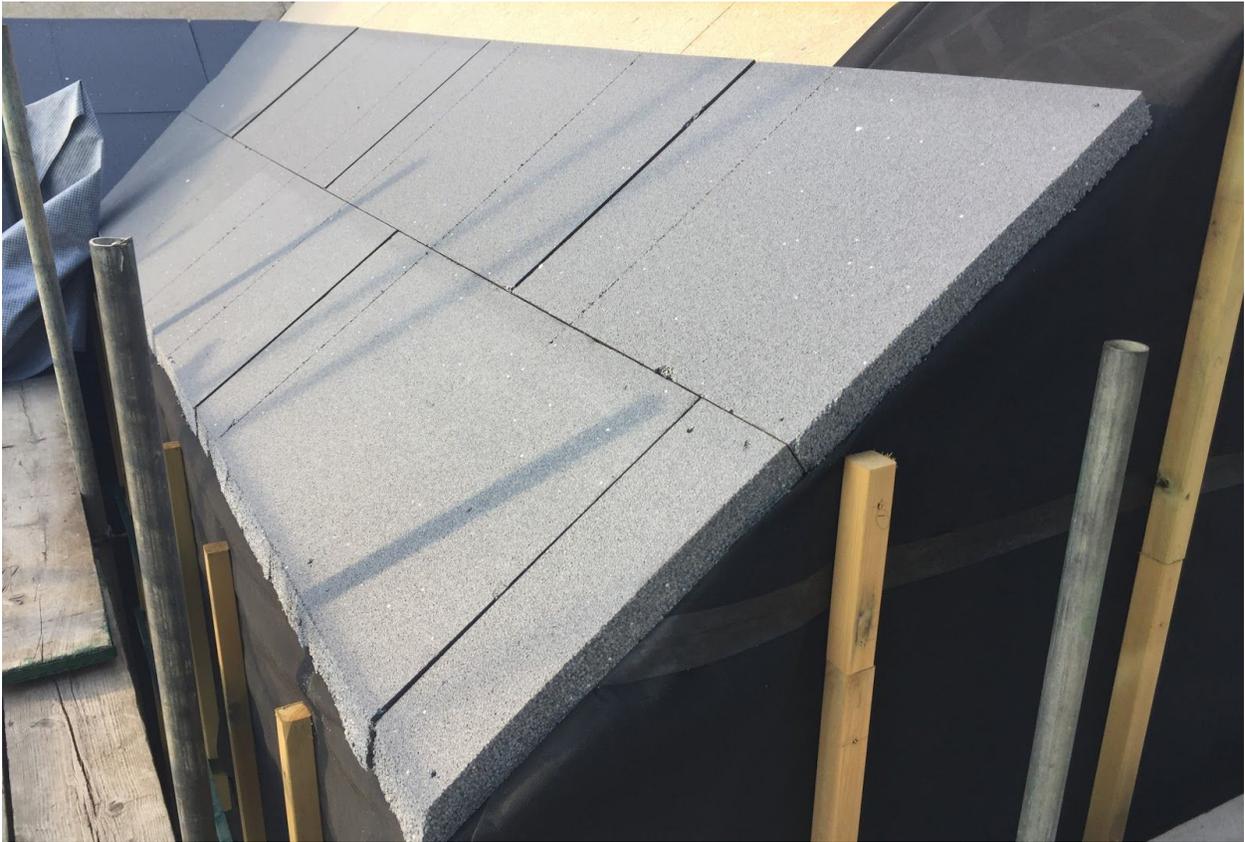
VERGE DETAIL

ROOF DATA

	λ W/(mK)	mm
CLT	0.130	100
Mineral wool insulation (with timber fraction)	0.034	400
Platinum EPS sarking	0.032	50

U-VALUE

0.076 W/(m²K)

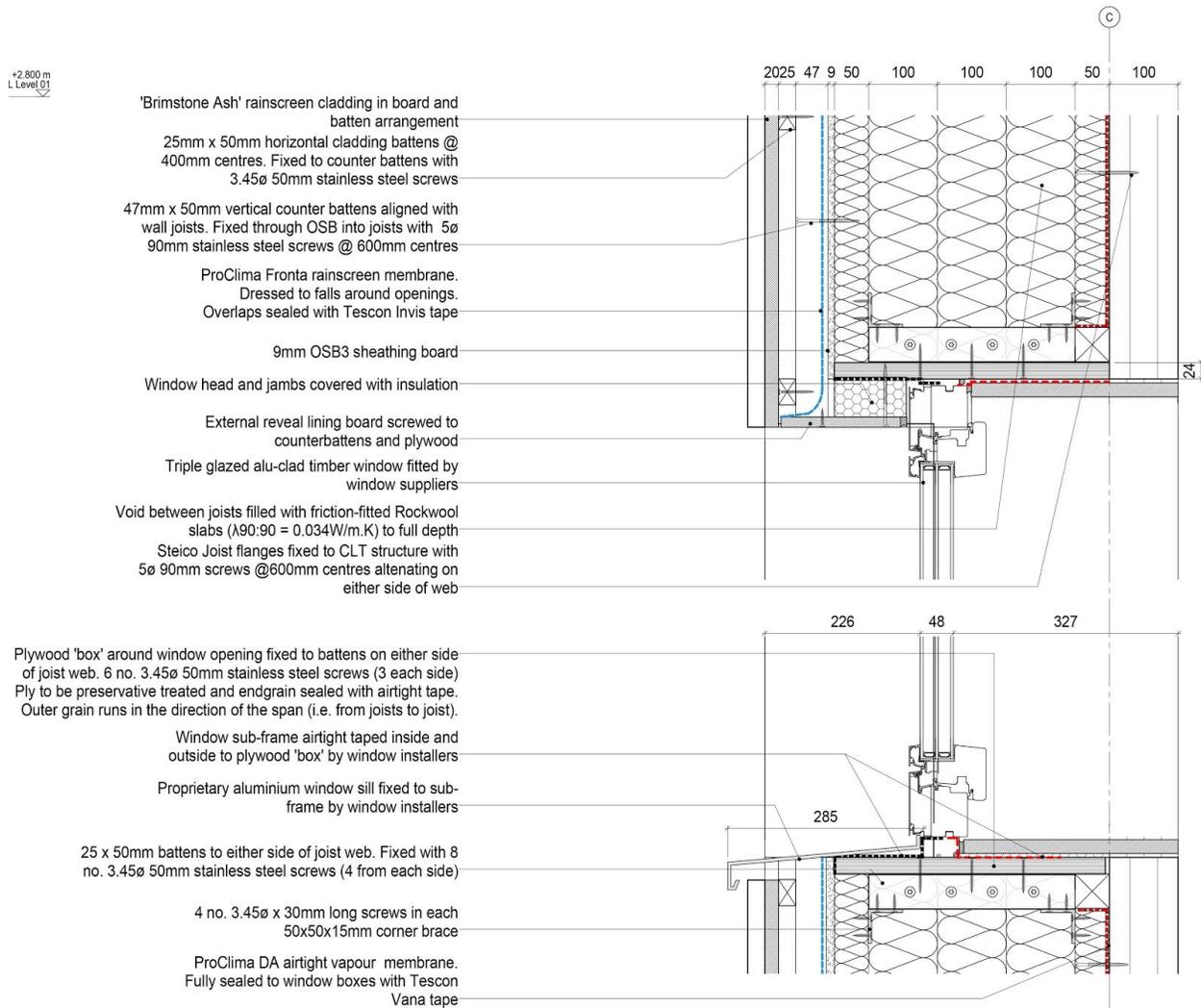


Construction photo showing EPS sarking temporarily pinned over OSB sheathing, prior to roof battens and membrane fixing



Construction photo nearing completion of the roof, showing reclaimed slates and concealed gutter

5.4 WINDOW SECTION



The windows, sliding door and entrance door were supplied and installed by Internorm. HF310 windows are timber-aluminium composite with an average U_f -value of $0.790 \text{ W}/(\text{m}^2\text{K})$. They open inward to allow wrapping of the frames externally with graphite EPS and are fixed into plywood boxes that cantilever out into the insulation zone and reduce the potential thermal bridging from installation. Glazing is triple glazed with warm edge spacers and an average U_g -value of $0.548 \text{ W}/(\text{m}^2\text{K})$.

WINDOW DATA

Triple low-e glazing with argon gas and ISO warm edge spacer. Timber aluminium composite frame.

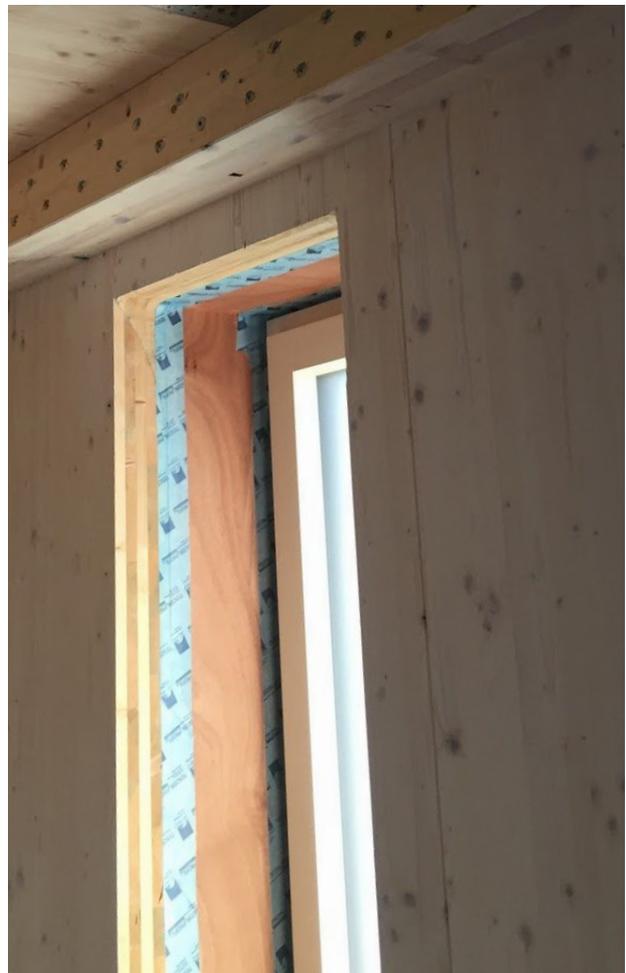
U-VALUE (average)	0.865 $\text{W}/(\text{m}^2\text{K})$
g-VALUE (average)	0.477

6.0 AIRTIGHTNESS RESULT

The airtightness strategy begins with the inherent air resistance of CLT panels - minimal joints due to large format components & multiple glued layers in different orientations. Junctions were designed as overlapped, then glued and over-taped on the external face by the frame contractor. Once the frame was in place, the roof and walls were covered in a ProClima DA membrane as a secondary airtight vapour check and temporary weatherproof line.

Windows and doors were surrounded with insulating foam by the installers and then sealed to their plywood 'box' surrounds and the main CLT frame with ProClima tapes.

The poured concrete structural slab completes the airtight line, laid over a radon membrane between the insulation and the concrete. The external wall membrane is sealed down onto the slab with ProClima Extoseal tape around the perimeter.



The airtightness was tested after these initial measures and then again at completion. Both tests were undertaken by Melin Energy Consultants and the final n_{50} result averaged 0.28 h-1 (0.27 pressurisation, 0.29 depressurisation) @ 50 Pa.



Pressurize Data Set

Test Dataset Date and Time: 2019-09-25-10:22:00

Environmental Conditions		
Wind speed:	0	from the
Operator Location:	Inside the building	
Initial Bias Pressure:	-0.95 Pa	
Initial Temperature:	indoors: 23.9	outdoors: 16.1.
Final Bias Pressure:	-0.97 Pa	
Final Temperature:	indoors: 24.2	outdoors: 17.4.
Barometric Pressure:	98.4 kPa	
	from Direct measurement	

Test Analysis		
Correlation, r^2 :	99.367	95% confidence limits
Slope, n:	0.906	0.83342 0.97781
Intercept, C_{int} [$m^3/h/m^2$]:	2.8026	2.106 3.729
	Results	Uncertainty
Air flow at 50 Pa, Q_{50} m^3/h	96.456	+/-1.6%
Air changes, n_{50} :	0.2681	+/-1.6%
Equivalent leakage area at 50 Pa [cm^2]	7.994	+/-1.6%
Permeability at 50 Pa, AP_{50} [$m^3/h/m^2$]	0.2431	+/-1.6%

Induced pressure [Pa]		34.7	40.4	44.7	49.6	54.4	60.4	64.4	70.0				
#1, Range C1	Fan Pressure [Pa]	51.4	61.7	69.1	76.9	86.8	96.0	106.5	118.0				
	Flow [m^3/h]	68.15	79.00	85.79	91.85	101.9	107.9	119.5	129.4				
Error [%]		-0.1%	1.3%	0.6%	-1.8%	0.3%	-3.2%	1.2%	1.7%				

Static Pressure Averages:			
initial [Pa]	$\Delta P01$ -0.95	$\Delta P01$ -1.08	$\Delta P01$ + 0.20
final [Pa]	$\Delta P02$ -0.97	$\Delta P02$ -1.63	$\Delta P02$ + 0.57

Air Leakage Test Data Appendix-

Depressurize Data Set

Test Dataset Date and Time: 2019-09-25-10:46:34

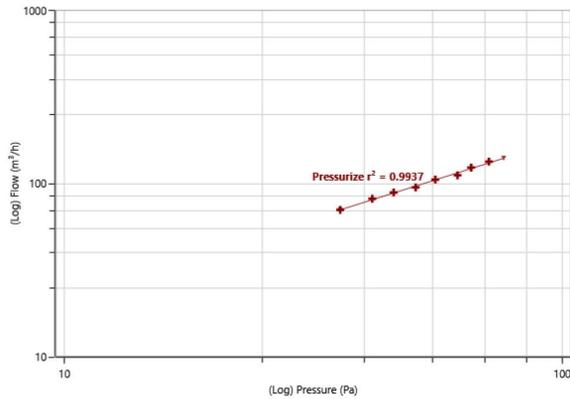
Environmental Conditions		
Wind speed:	0	from the
Operator Location:	Inside the building	
Initial Bias Pressure:	-1.22 Pa	
Initial Temperature:	indoors: 23.7	outdoors: 16.1.
Final Bias Pressure:	-0.95 Pa	
Final Temperature:	indoors: 23.9	outdoors: 16.1.
Barometric Pressure:	98.4 kPa	
	from Direct measurement	

Test Analysis		
Correlation, r^2 :	99.294	95% confidence limits
Slope, n:	0.727	0.66569 0.78819
Intercept, C_{int} [$m^3/h/Pa^n$]:	6.0335	4.690 7.762
	Results	Uncertainty
Air flow at 50 Pa, Q_{50} m^3/h	103.22	+/-1.7%
Air changes, n_{50} :	0.2869	+/-1.7%
Equivalent leakage area at 50 Pa [cm^2]	18.86	+/-1.7%
Permeability at 50 Pa, AP_{50} [$m^3/h/m^2$]	0.2602	+/-1.7%

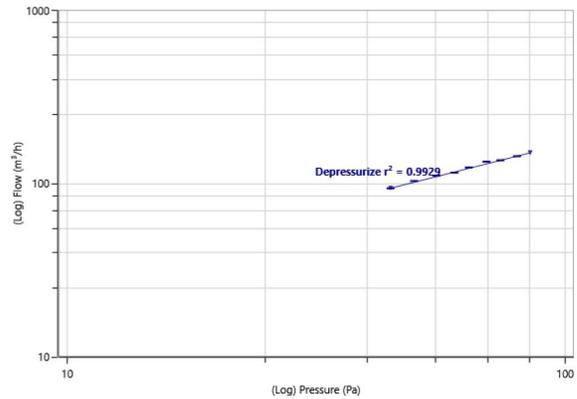
Induced pressure [Pa]		-45.5	-50.6	-56.0	-60.8	-64.9	-70.3	-74.9	-80.8				
#1, Range C1	Fan Pressure [Pa]	27.8	32.6	36.6	39.1	43.8	49.7	51.2	56.0				
	Flow [m^3/h]	92.87	102.3	109.7	114.2	122.4	132.1	134.5	142.1				
Error [%]		-0.8%	0.9%	0.4%	-1.6%	0.4%	2.2%	-0.7%	0.8%				

Static Pressure Averages:			
initial [Pa]	$\Delta P01$ -1.22	$\Delta P01$ -1.22	$\Delta P01$ + 0.00
final [Pa]	$\Delta P02$ -0.95	$\Delta P02$ -1.08	$\Delta P02$ + 0.20

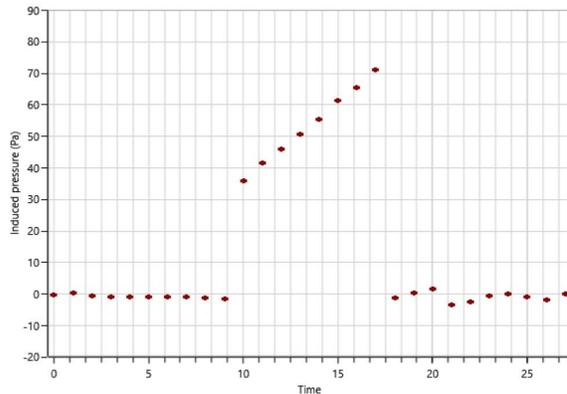
Induced Pressure vs. Flow (Pressurize Set)



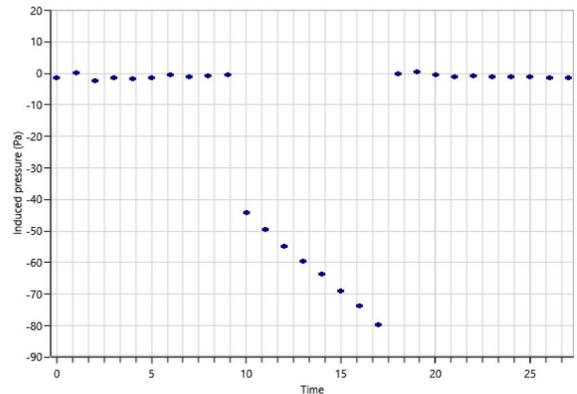
Induced Pressure vs. Flow (Depressurize Set)



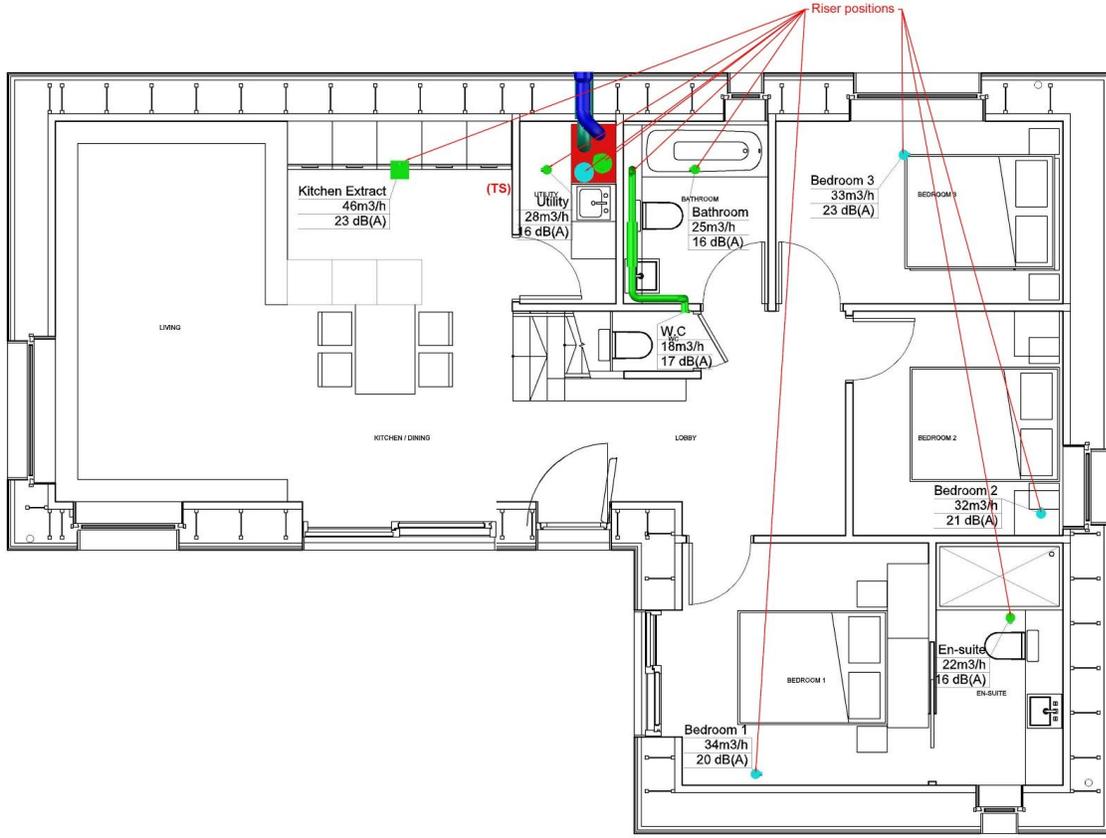
Building Gauge Pressure (Pressurize Set)



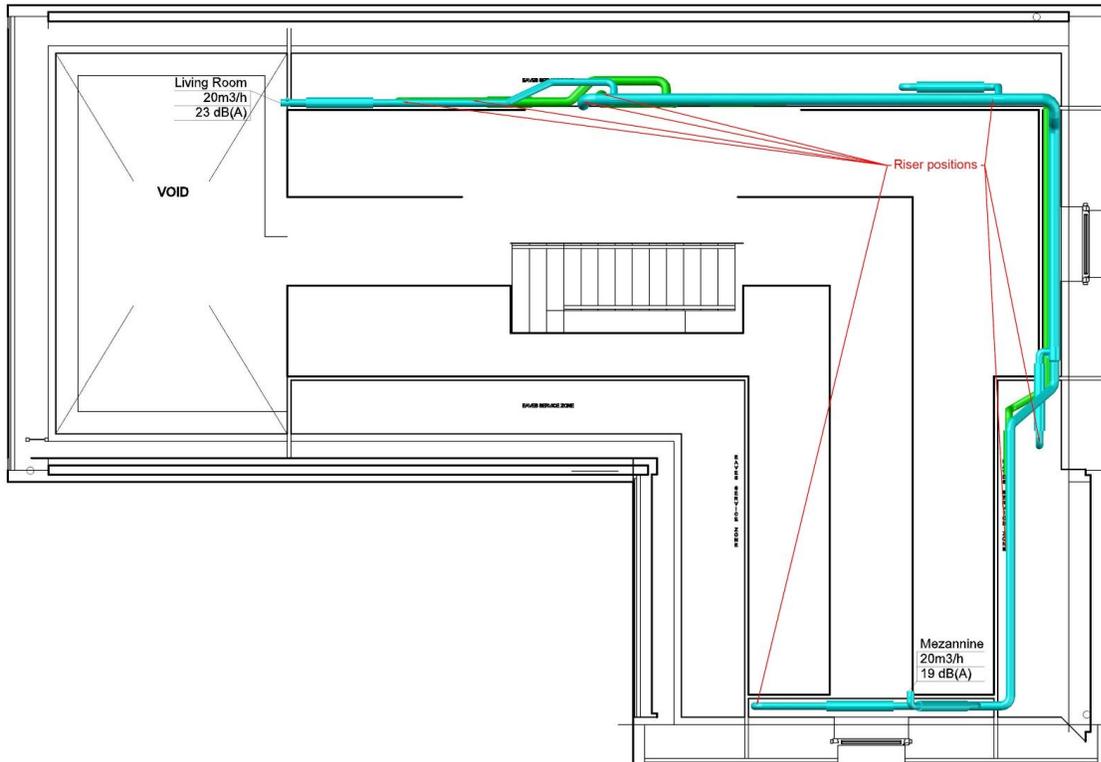
Building Gauge Pressure (Depressurize Set)



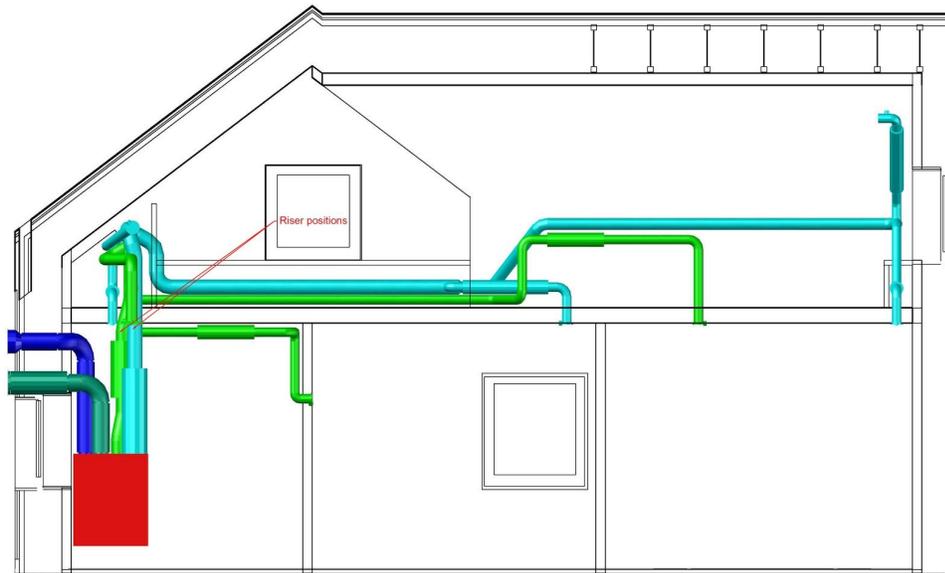
7.0 VENTILATION



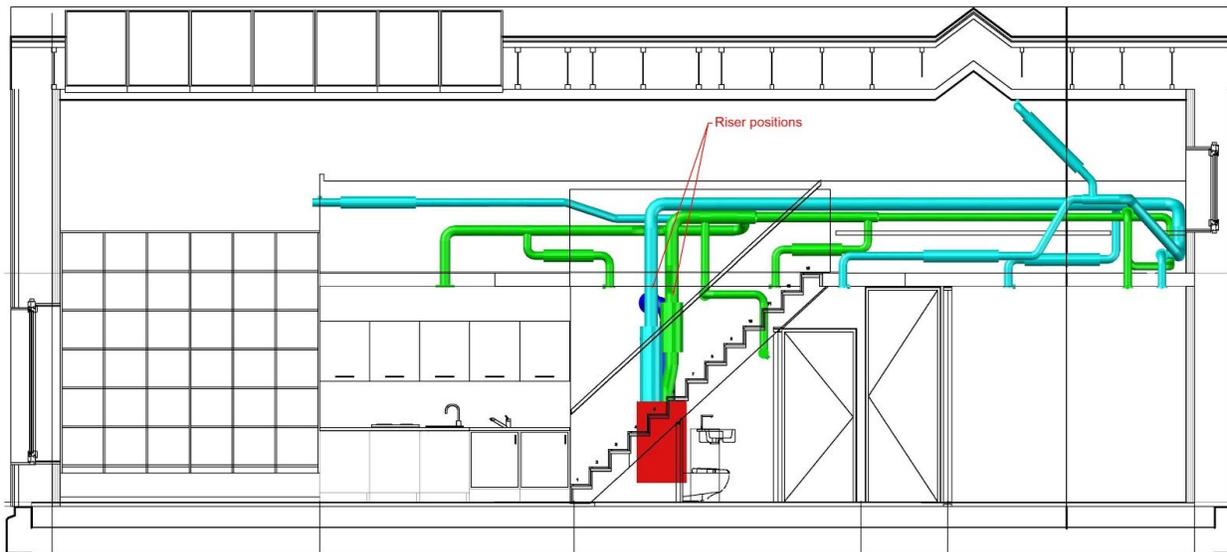
Ground Floor ventilation layout



First Floor ventilation layout



Short section



Long section

KEY: MVHR (red), Intake (navy), Exhaust (dark green), Supply (turquoise), Extract (green)

A Paul Novus 300 MVHR unit is located in the Utility Room at Ground Floor in order to be close to the external wall and roughly central in plan. The cooker hood is recirculating with a charcoal filter. The intake and exhaust are wrapped in 15mm pre-formed EPS insulation and a layer of 25mm taped armafex lagging. The effective heat recovery efficiency is 90.6% with a specific power input of 0.24 Wh/m^3

Lindab rigid steel spiral wound ducts are used for distribution, with cross-talk attenuation to habitable rooms. The structural frame connections between First Floor, roof and walls are notched to allow larger ducts to pass over. This keeps all services within the eaves perimeter zone below 1m height, which is ignored in TFA calculations, thus maximising usable floor area.

Fresh air is supplied to all bedrooms, the living area and the mezzanine floor. It is extracted from wet rooms (bathroom, en-suite, kitchen), using the lobby as a transfer path.



Construction photos of the duct install and terminal commissioning and a photo of the MVHR unit in place.

8.0 HEAT SUPPLY

Space heating is supplied by two 600w electric panel heaters (Mill NE600) which are Wi-Fi controlled with manual override. One is located in the hallway outside the three bedrooms, the other in the main living space.

Domestic hot water is supplied through two SunAmp UniQ heat batteries. The larger 6kWh unit is located in the Utility room and feeds the kitchen and main bathroom. A secondary 3kWh unit is located in the En-Suite bathroom to supply the shower and sink here. Both store excess electricity from the roof-integrated PV array.



Construction photo of a panel heater (living space) and heat battery (en-suite) installed.

9.0 PHPP CALCULATIONS

Passive House verification					
					
Building:	Deasil				
Street:	The Downs				
Postcode / City:	BA3 3DD Clandown				
Country:	United Kingdom				
Building type:	Detached House				
Climate:	[UK] - Severn (Lyneham)	Altitude of building site (in [m] above sea level):	140		
Home owner / Client:	Tom Fowlie				
Street:	Deasil, The Downs				
Postcode/City:	BA3 3DD Clandown				
Architecture:	Tom Fowlie				
Street:	Deasil, The Downs				
Postcode / City:	BA3 3DD Clandown				
Mechanical system:	Green Building Store				
Street:	Heath House Lane, Golcar				
Postcode / City:	HD7 4JW Huddersfield				
Year of construction:	2018	Interior temperature winter:	20.0	°C	Enclosed volume V_e m ³ :
No. of dwelling units:	1	Interior temperature summer:	25.0	°C	Mechanical cooling:
No. of occupants:	3.3	Internal heat sources winter:	2.5	W/m ²	
Spec. capacity:	72	Wh/K per m ² TFA	Ditto summer:	2.4	W/m ²
Specific building demands with reference to the treated floor area					
	Treated floor area	114.3	m ²	Requirements	Fulfilled?*
Space heating	Heating demand	14	kWh/(m ² a)	15 kWh/(m ² a)	yes
	Heating load	9	W/m ²	10 W/m ²	yes
	Frequency of overheating (> 25 °C)	0.8	%	-	-
Primary energy	Heating, cooling, dehumidification, DHW, auxiliary electricity, lighting, electrical appliances	104	kWh/(m ² a)	120 kWh/(m ² a)	yes
	DHW, space heating and auxiliary electricity	73	kWh/(m ² a)	-	-
	Specific primary energy reduction through solar electricity	20	kWh/(m ² a)	-	-
Airtightness	Pressurization test result n ₅₀	0.3	1/h	0.6 1/h	yes
* empty field: data missing; '-': no requirement					
Passive House?					yes
<p>We confirm that the values given herein have been determined following the PHPP methodology and based on the characteristic values of the building. The PHPP calculations are attached to this application.</p>		<p>Name: Sally</p> <p>Surname: Godber</p> <p>Company: WARM</p>		<p>PHPP Version 8.5</p> <p>Issued on: 20/12/2019</p> <p>Signature:</p>	

10.0 CONSTRUCTION COSTS

Including fit-out, the total construction cost was approximately £2,800/m² of Treated Floor Area.

11.0 MEASURED RESULTS

11.1 MEASURED ENERGY CONSUMPTION VALUES

Total electricity consumption (space heating, lighting, appliances, DHW etc.) was metered at 4064 kWh for the period January 2019 - January 2020, which equates to approx. 36 kWh/(m²a) when divided by the TFA (114m²).

In the same period the rooftop PV generated around 3700 kWh, but we do not have the data to determine how much of this was utilised directly on site vs. exported to the grid.

11.2 CONSTRUCTION PERIOD

November 2017 to December 2018

11.3 USER SATISFACTION

Gemma Fowle, project manager and occupant:

The internal temperature of the house is incredibly stable, not dipping below 17°C overnight in the coldest months even when the heaters are off and it's sub- zero outside. During the winter we obtain all the heat we need from two small panel heaters and the residual heat from our usual appliances, taking that 17°C to a comfortable 21°C on average. We don't aim to heat the house much more than that, preferring to add an extra jumper! We run the panel heaters during the day so the PV takes whatever solar energy is available, and then turn them off when we are in bed to minimise the running cost.

During the summer, in full sun it is necessary for us to shade our largest windows in the middle of the day to minimise solar gain. We often open the windows for a breeze and the smells and sounds of the country. The through-draft gained from opening windows on the shaded side of the house is adequate to ensure that the house is cooler inside than outside.

Air quality overall is very good, it never feels stale, and we have no problems with dampness or mould. Clothes and even large duvet covers dry quickly and smell fresh. Paul, our MVHR unit, has been a trouble-free friend with no issues, and the sound of the MVHR is very unobtrusive - if we ever hear it, the filters probably need a clean. We live in a quiet place here, but never suffer from noise even when our neighbours are being loud, because of the triple glazing. We're also fairly exposed on the edge of a valley, but there are no draughts even when in the windiest weather.