

Submission for renewal of CEPH Designer qualification by Paul Mallion, BSc(Hons) MSc(Arch) FRICS

Project Documentation :

The Den, Ansty, Dorset.

First issue 16 Jan 2017.

Revised 18 Feb 2017

Revised 28 March 2017

1 Abstract



Detached three bedroom house in Dorset, England

1.1 Data of building

Year of construction	2014	Space heating / Heizwärmebedarf	11 kWh/(m²a)
U-value external wall/ U-Wert Außenwand	0.125 W/(m ² K)		
U-value basement ceiling/ U-Wert Kellerdecke	0.117 W/(m ² K)	Primary Energy Renewable (PER) / Erneuerbare Primärenergie (PER)	kWh/(m ² a)
U-value roof/ U-Wert Dach	0.111 W/(m ² K)	Generation of renewable energy / Erzeugung erneuerb. Energie	kWh/(m ² a)
U-value window/ U-Wert Fenster	0.88 W/(m ² K) ¹	Non-renewable Primary Energy (PE) / Nicht erneuerbare Primärenergie (PE)	120 kWh/(m ² a)
Heat recovery	89 %	Pressure test n ₅₀	0.6 h ⁻¹
Special features	Solar collectors for hot water generation, PV panels for electricity generation		

¹ Corrected on 18th Feb 2017.

1.2 Brief Description

The Den, Ansty, Dorset

The design brief was simple:- an affordable, easy to build, 3 bed Passivhaus on a challenging small site.

The site was next to The Fox pub in Ansty, Dorset:-

- to the east was a steel clad pig barn;
- to the south, the pub car park and site access;
- to the west, limited views at ground level, but great views at first and second floor level;
- to the north, muddy fields of pigs and rheas, views of rolling hills beyond, and a major drainage issue from surface runoff.

Budget was very limited and the client/contractor had no previous passivhaus experience, although were used to building to a high standard using conventional methods.

The design had to be focused on the good views to the west and allow solar gain to the south, but risked both overheating and lack of privacy for the same reasons. It was decided to place the living room at first floor level along with the master bedroom, leaving the ground floor clear for the kitchen, dining, utility and two bedrooms.

A mezzanine floor was created at the east end above the first floor for a home office, overlooking a double height living room and providing views through the large west windows. This slightly increased the heat loss form factor but improved daylighting in the living area.

The circulation spaces are minimized by the open plan layout, yet privacy is maintained to the bedrooms. The house is located at the far east end of the 0.19 acre site, creating a feeling of space on the small plot.

Regrettably during the recession the timber frame fabricator went bust just before delivery to site, almost killing off the project at a critical stage.

1.3 Responsible project participants / Verantwortliche Projektbeteiligte

Architect/ Entwurfsverfasser	Paul Mallion, Conker Conservation Ltd http://www.conker.cc
Implementation planning/ Ausführungsplanung	Paul Mallion, Conker Conservation Ltd http://www.conker.cc
Building systems/ Haustechnik	All Timber Frames Ltd
Structural engineering/ Baustatik	S.C. Green Ltd
Building physics/ Bauphysik	Paul Mallion, Conker Conservation Ltd http://www.conker.cc
Passive House project planning/ Passivhaus-Projektierung	Paul Mallion, Conker Conservation Ltd http://www.conker.cc
Construction management/ Bauleitung	Dennis Merrigan, Principle Contracts
Certifying body/ Zertifizierungsstelle	Warm Low Energy Building Practice www.peterwarm.co.uk
Certification ID/ Zertifizierungs ID	Project-ID 5197(www.passivehouse-database.org)
Author of project documentation / Verfasser der Gebäude-Dokumentation	Paul Mallion ² paul@conker.cc
Date, Signature/ Datum, Unterschrift	18 February 2017 

² Name and email inserted 18th Feb 2017

2 Photographs



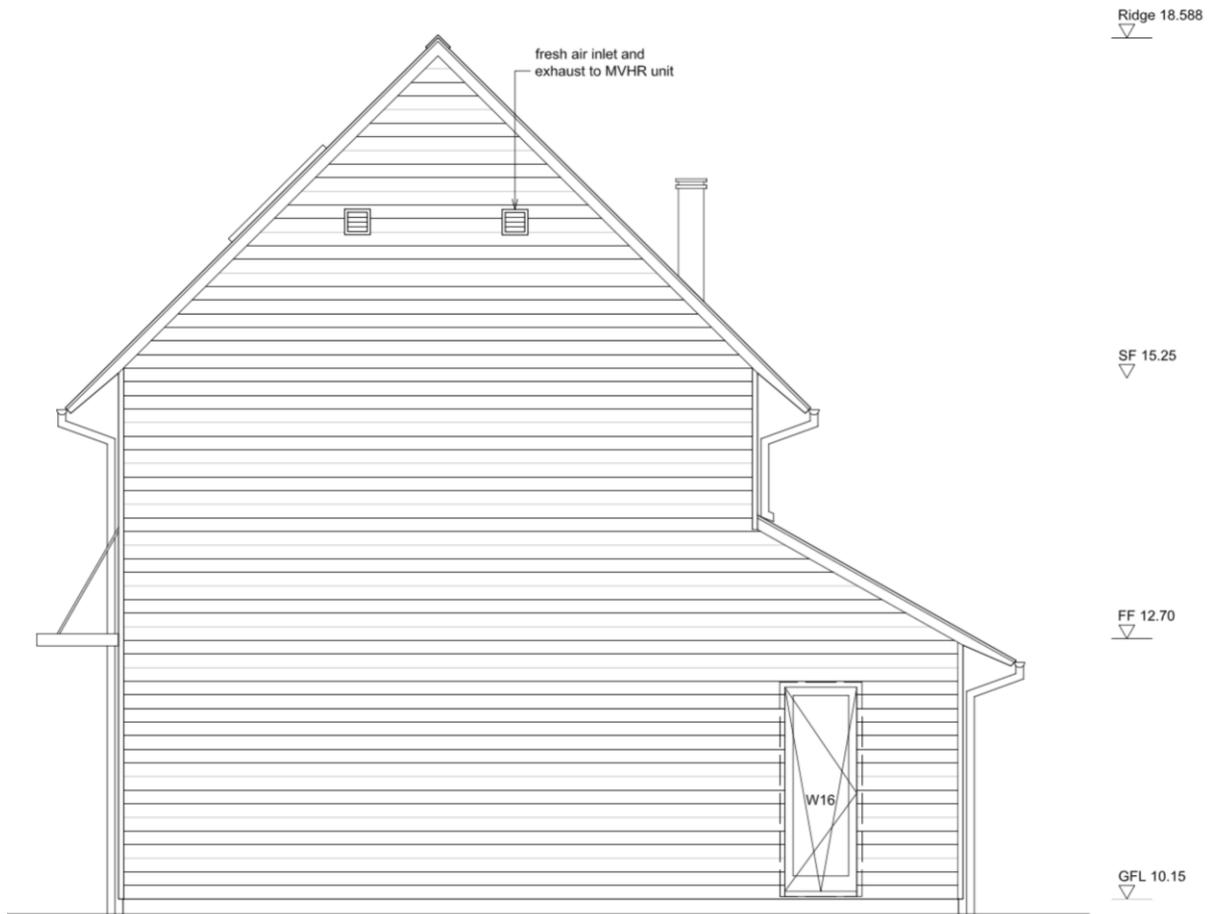
South elevation: main entrance door in centre. Sliding doors to main rooms and fixed window to stairwell above entrance. Fixed solar shading over ground floor windows. Deep roof overhang.



View from north west: Large west facing windows enjoy good views over countryside. Deep roof overhang, fixed shading and balcony provide shading.

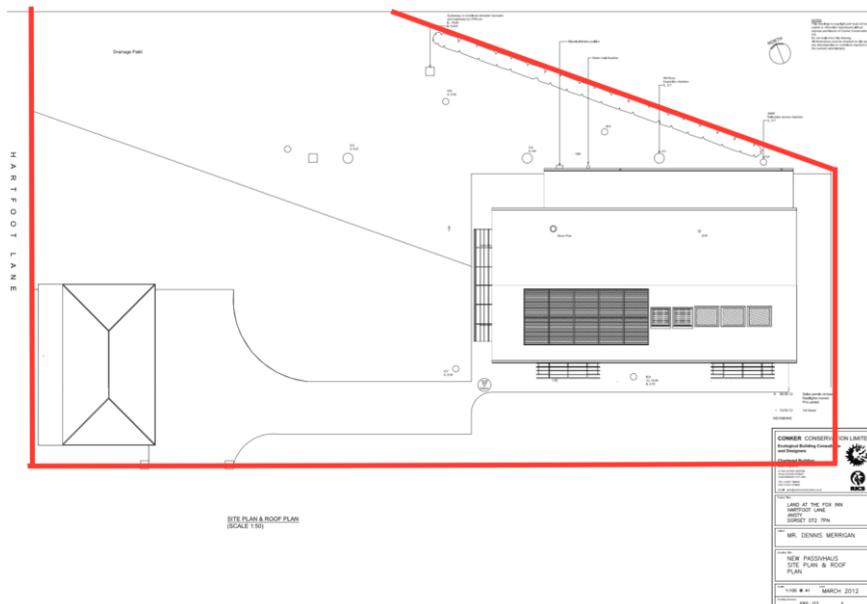


West view: showing solar shading. Decking in foreground covers aeration sewage treatment plant.



EAST ELEVATION
(SCALE 1:50)

East view. The dwelling is located very close to the East site boundary on which is there is a pig farm and barn. It is not possible to access the adjoining site to take a photograph. The above image is from the design drawings.



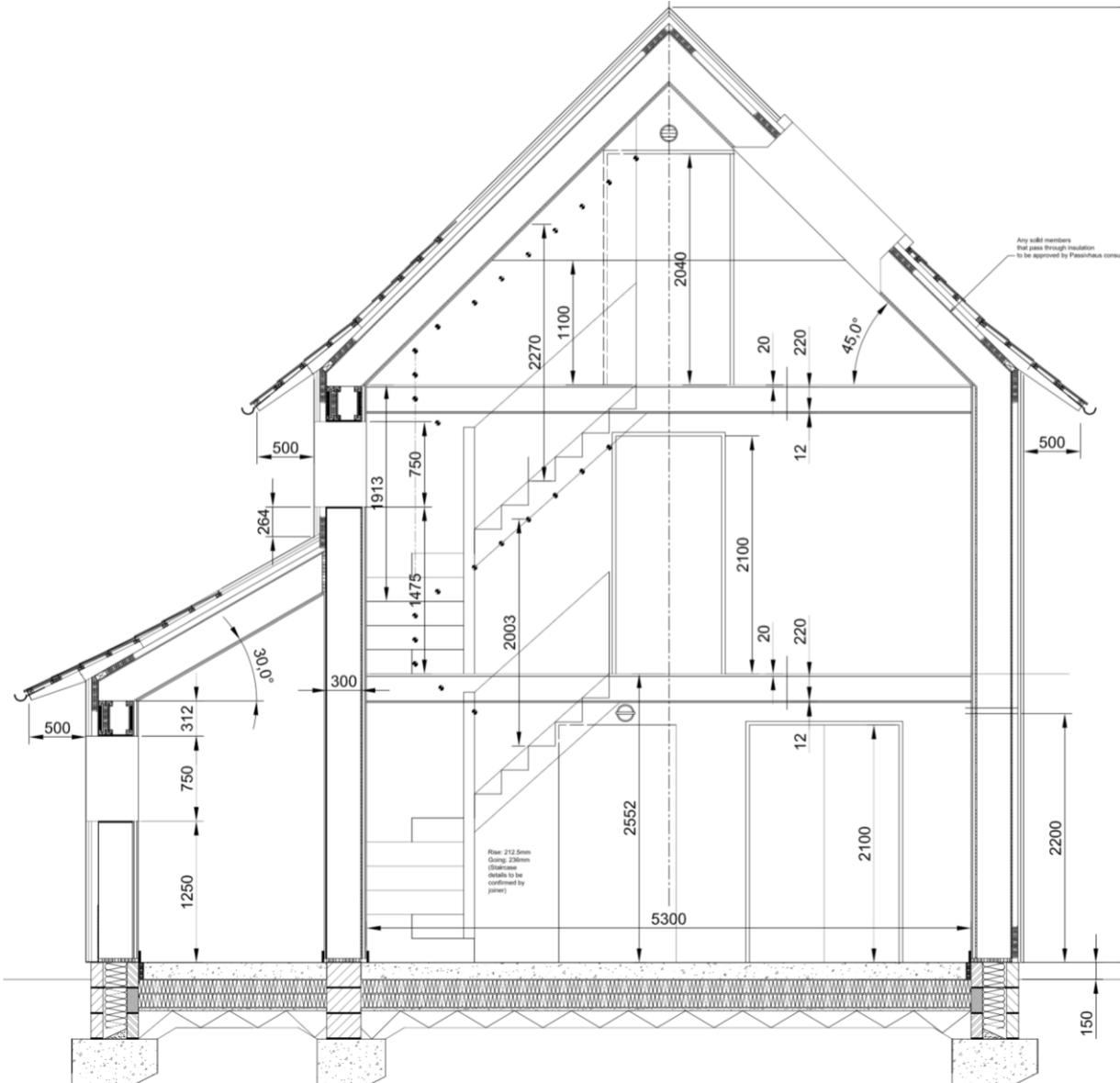
The plan to the left shows the site boundaries in red, indicating how close the East elevation is to the edge of the site.



Internal view of main living space and wood stove in corner.

3 Sectional drawings

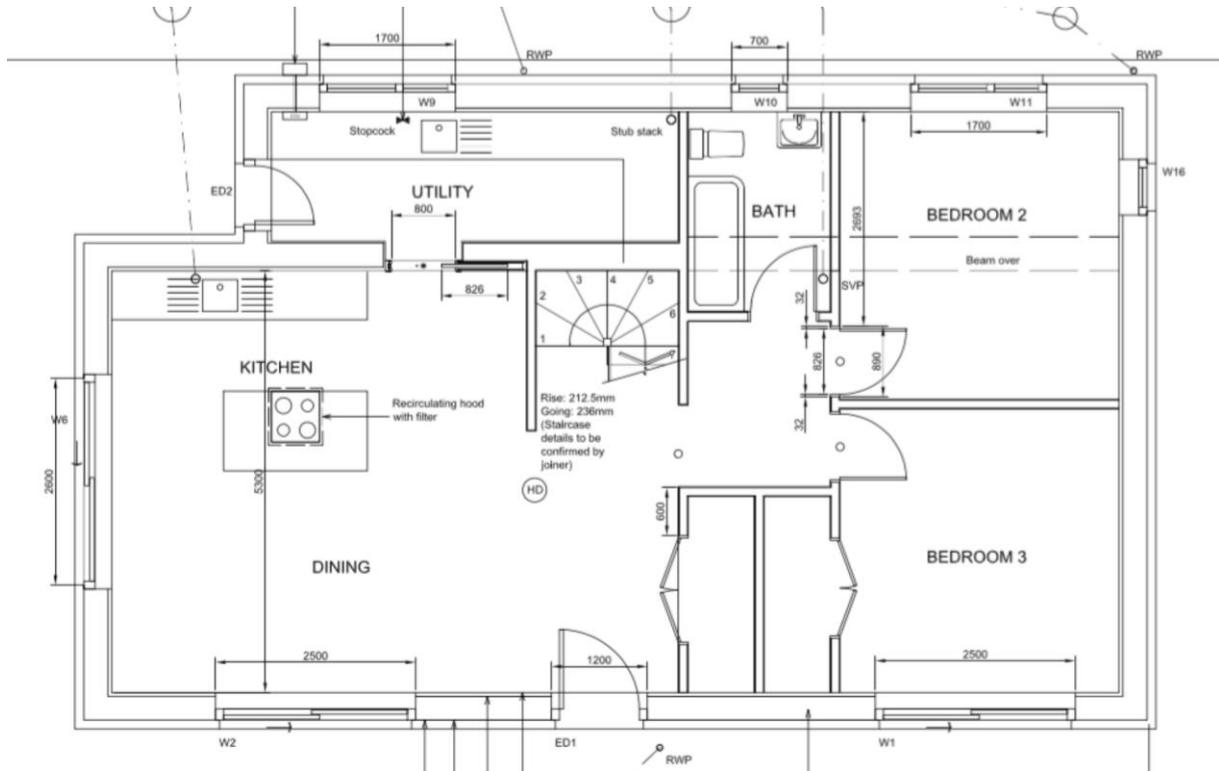
3.1. Cross section drawing 486-05



3.2. Drawing shows a simple timber frame using 300mm I joists for walls, roof and intermediate floors. The junctions between ground floor/wall, wall/roof are shown on the detail drawings listed later.

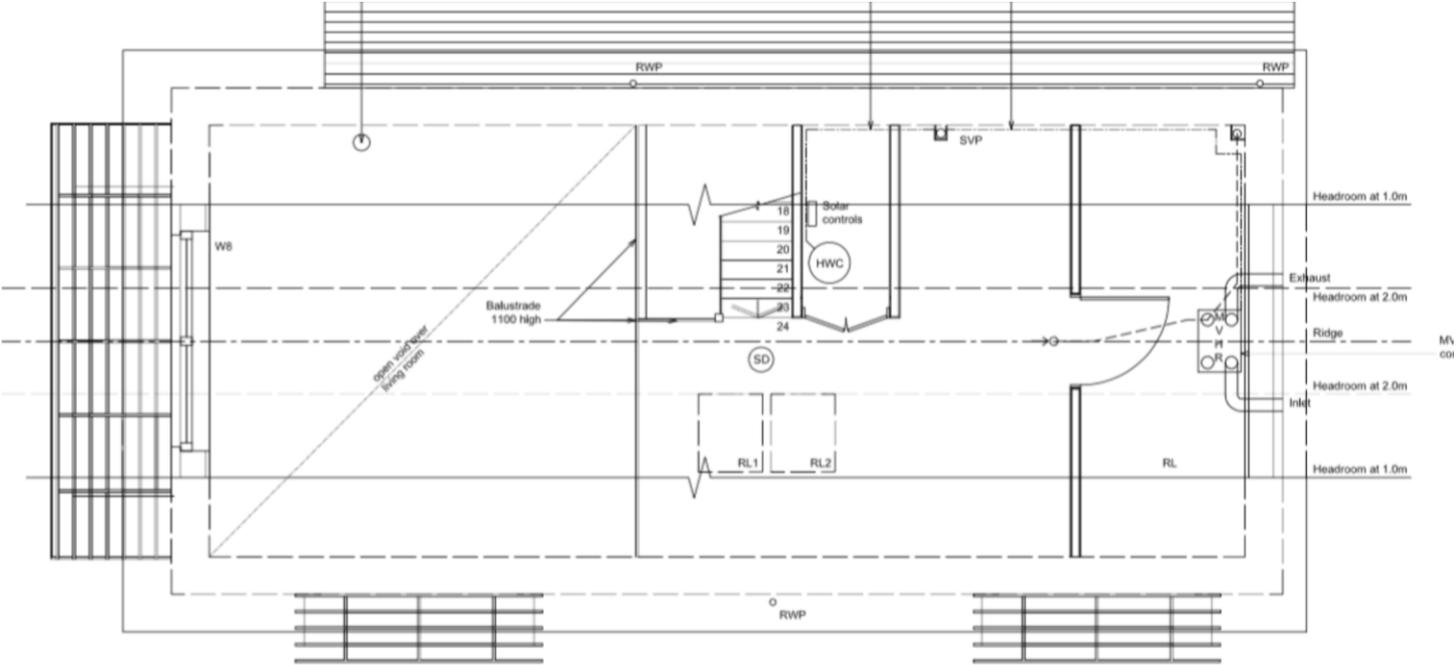
4 Floor plans

- 4.1. Proposed ground floor plan. The kitchen and utility room are on the ground floor, but also two bedrooms, as these rooms do not need to enjoy the views which are best from the floors above. The ground floor is also slightly cooler



owing to the thermal mass of the concrete floor slab. The utility room is on the north side of the house and also acts as a draught lobby and entrance for the owners. Bedroom 2 has the only east facing window, exploiting a narrow view of the hillside beyond the neighbouring pig shed. All the north facing windows are very shallow and wide, for good daylight but small overall area.

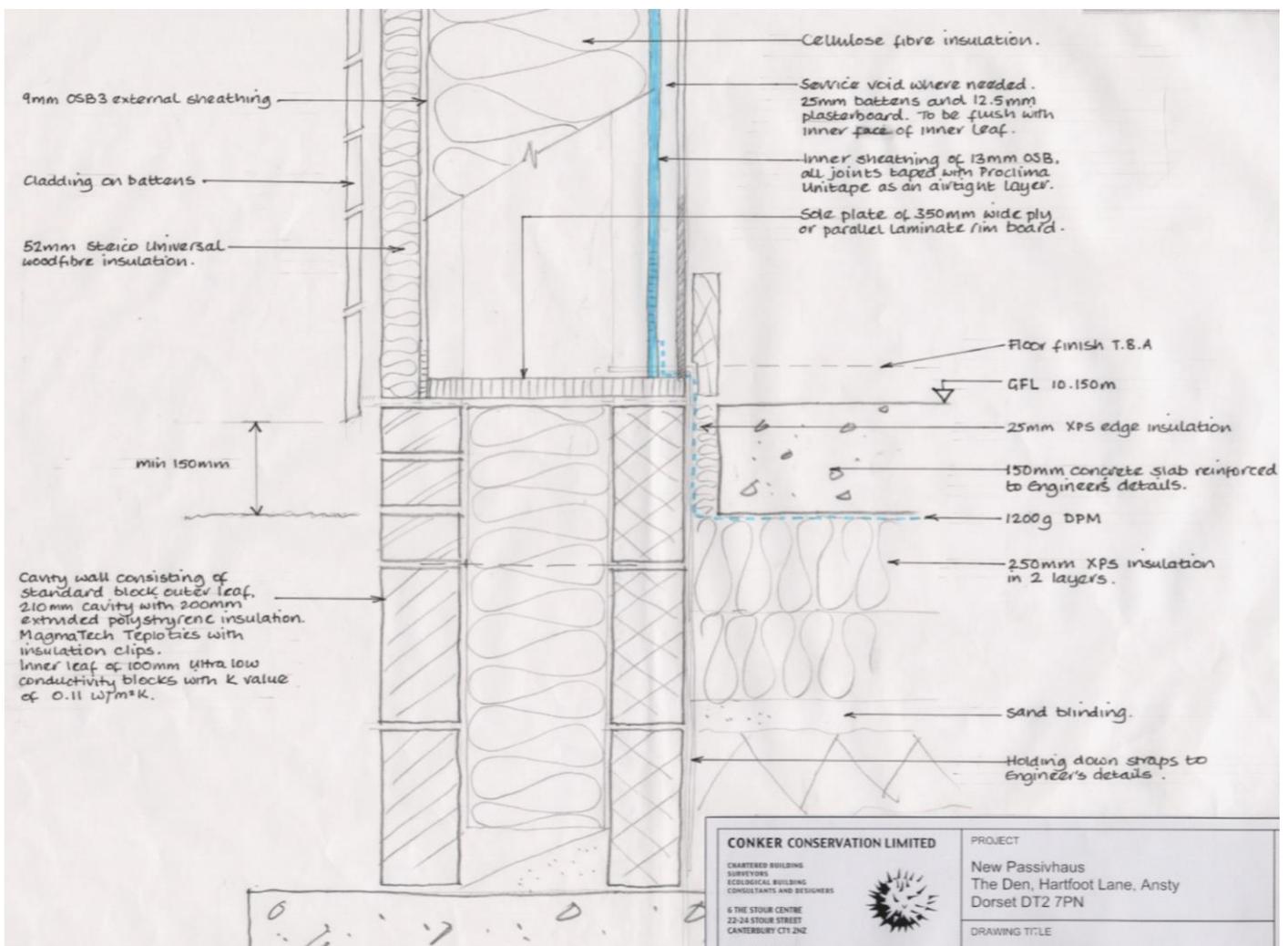
4.3. Second floor plan. At the top of the stairs is a mezzanine area which serves as a home office, but can also be used as a spare bed space. The plant room is at the east end. At the west end the floor is open to the floor below.

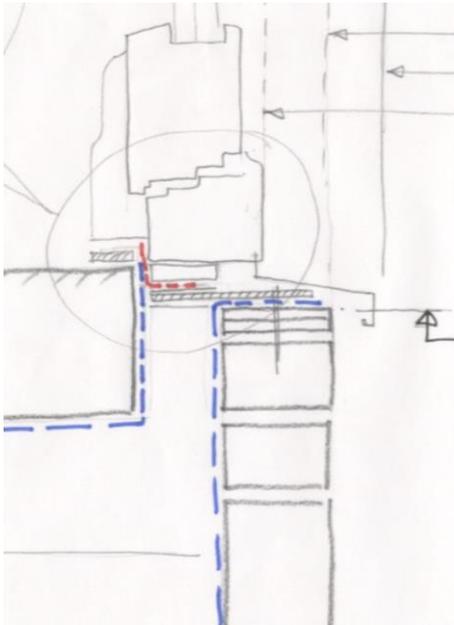


5 Description of construction

5.1 Floor slab/wall junction.

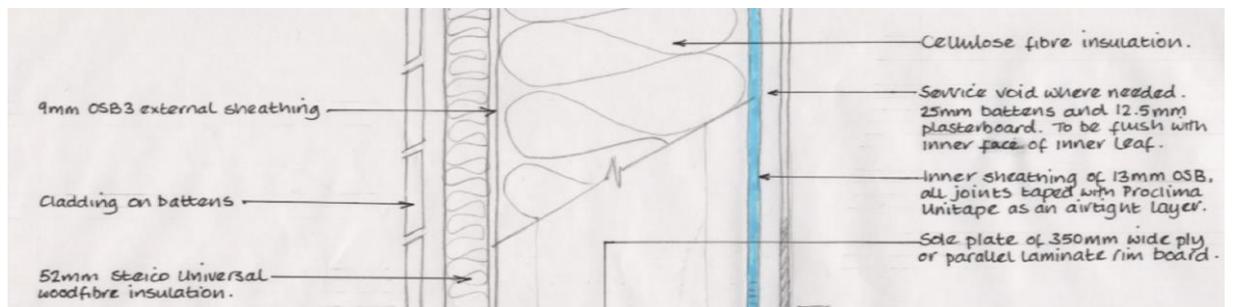
- 5.1.1 The ground floor is constructed as follows: 150mm reinforced concrete; damp proof membrane; 250mm XPS insulation; 25mm blinding and 150mm hardcore. The concrete was polished shortly after being laid and then had to be protected during the following works. This avoids the need for a screed. A cavity wall was used from the strip foundations up to damp proof course level, insulated with 200mm XPS and tied with low conductivity Teplo ties. Low conductivity blocks are used for the inner leaf, with a k value of 0.11 W/m²K. The cavity wall is capped with a sole plate for the timber frame.





- 5.1.2 Thresholds to the external doors are located over a strip of insulation to ensure no thermal bridges.

5.2 External walls.



- 5.2.1 The detail shows the 300mm wide 'I' joist (Steico SJ45 x 300) fully filled with insulation, and 52mm thick woodfibre sheathing board to the outside. A translucent fleece was fixed across the inside face of the timber frame before the insulation was injected, this allowed a full inspection of the insulation work to ensure no voids existed. The interior was then lined with OSB sheathing board. Due to the density of installation, the OSB pillows slightly between some of the studs, by battening (25mm thick) before plasterboarding the finish is perfectly flat.

5.2.2 Photograph showing injected insulation retained by fleece.



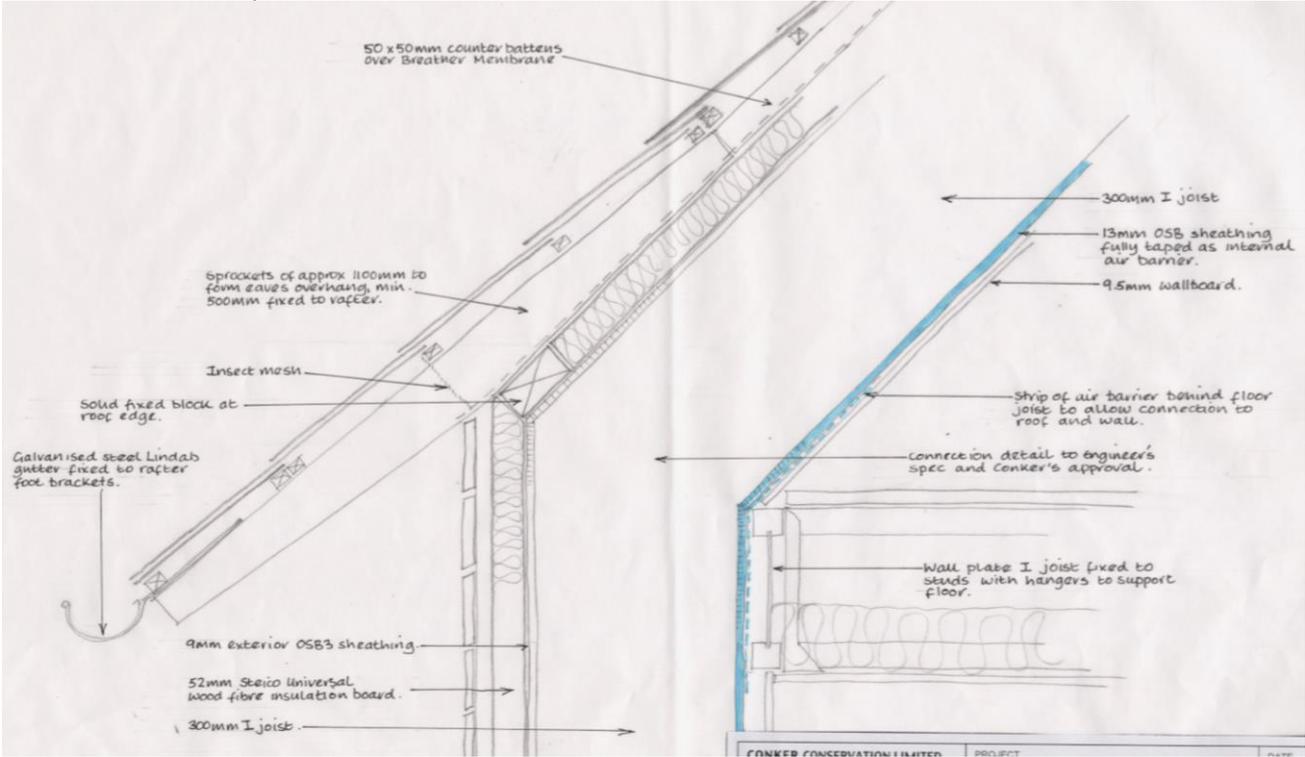
5.2.3 I was keen to avoid any steelwork in the structure so as to avoid cold bridges. Unfortunately the timber frame fabricator and their engineers were fairly traditional and would not entertain designing entirely without steel. A portal frame was required to the large west facing windows, but all other steel omitted. To mitigate the impact of the steelwork, I ensured that the steel was placed as close to the inside face as possible, with high performance insulation wrapped around it.

5.2.4 Steel frame for wind bracing. The airtight membrane can be seen placed underneath the wall plate, prior to the next level being raised.



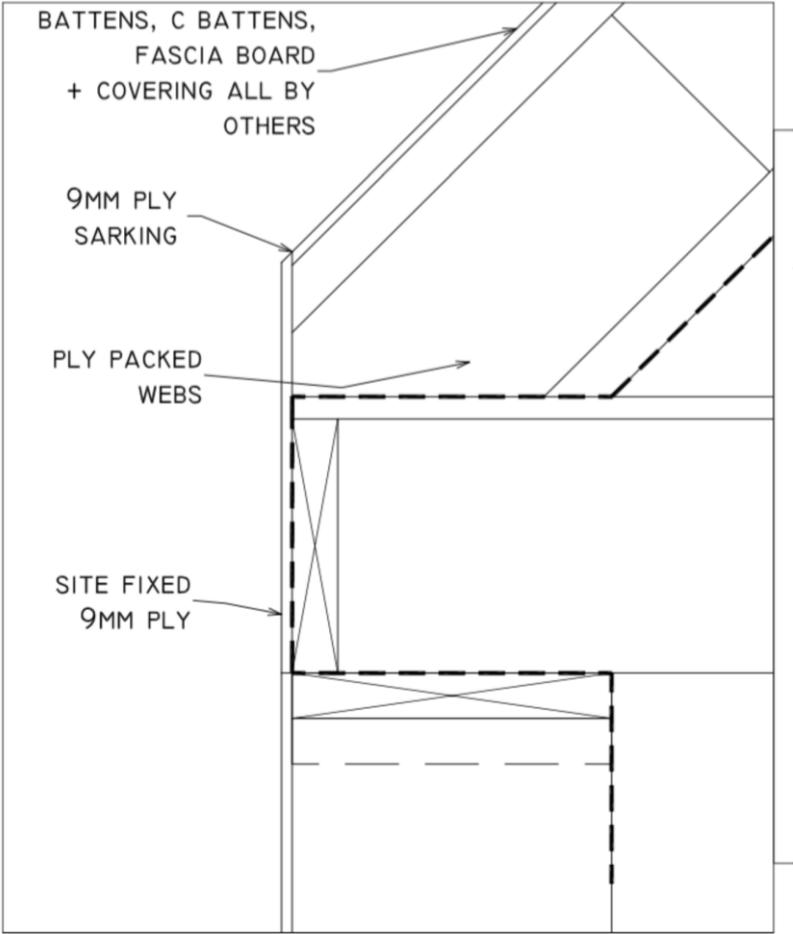
5.3 Roof

5.3.1 Roof construction is the same as the walls, apart from the finish. (300mm 'I' joists fully insulated with glass fibre, and 52mm dense woodfibre sarking insulation).

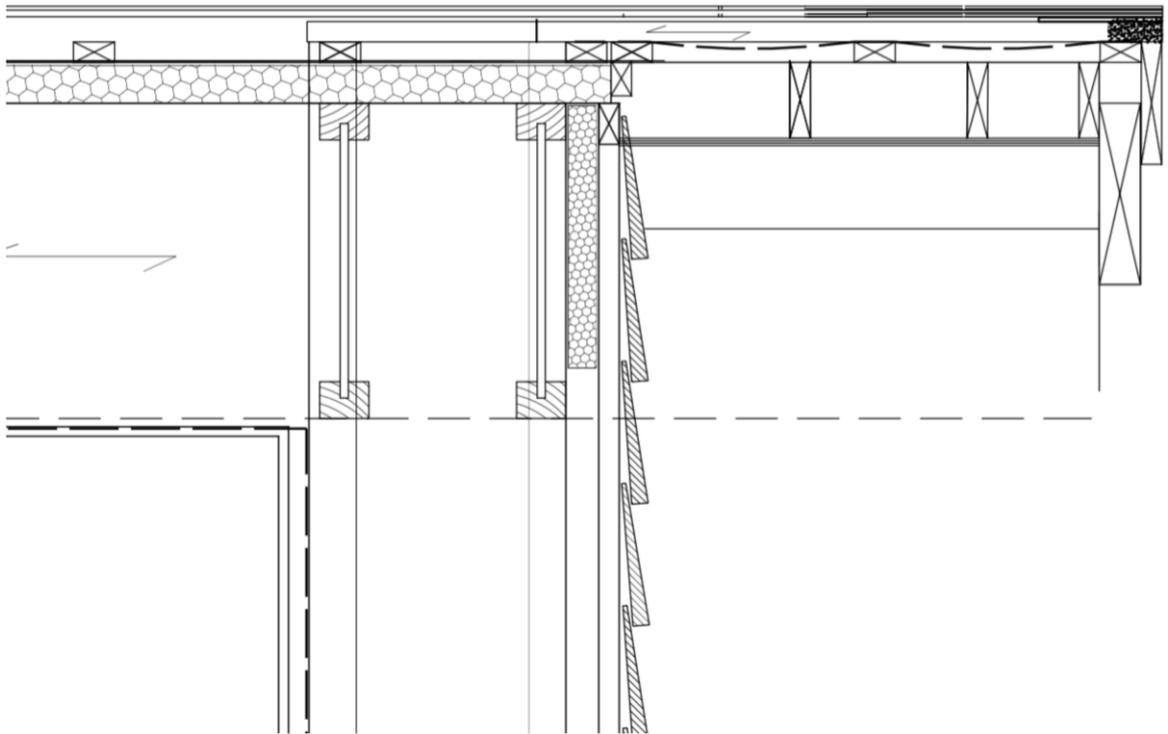


5.3.2 Sprockets are used on top of the roof surface to create the eaves overhang, without any components penetrating through the airtight, windtight or insulation layers. My original plan was to avoid using a traditional wall plate, but to use a portal frame principles with gussets joining the studs and rafters, as we did on the Greendale Studio Passivhaus. Unfortunately the timber frame contractor was not able to use this technique, so we settled for conventional construction using I joists, but paying careful attention to the placement of studs and the timber fraction.

5.3.3 Timber frame manufacturer's detail of the eaves junction, showing continuity of the airtight membrane around the second floor structure.



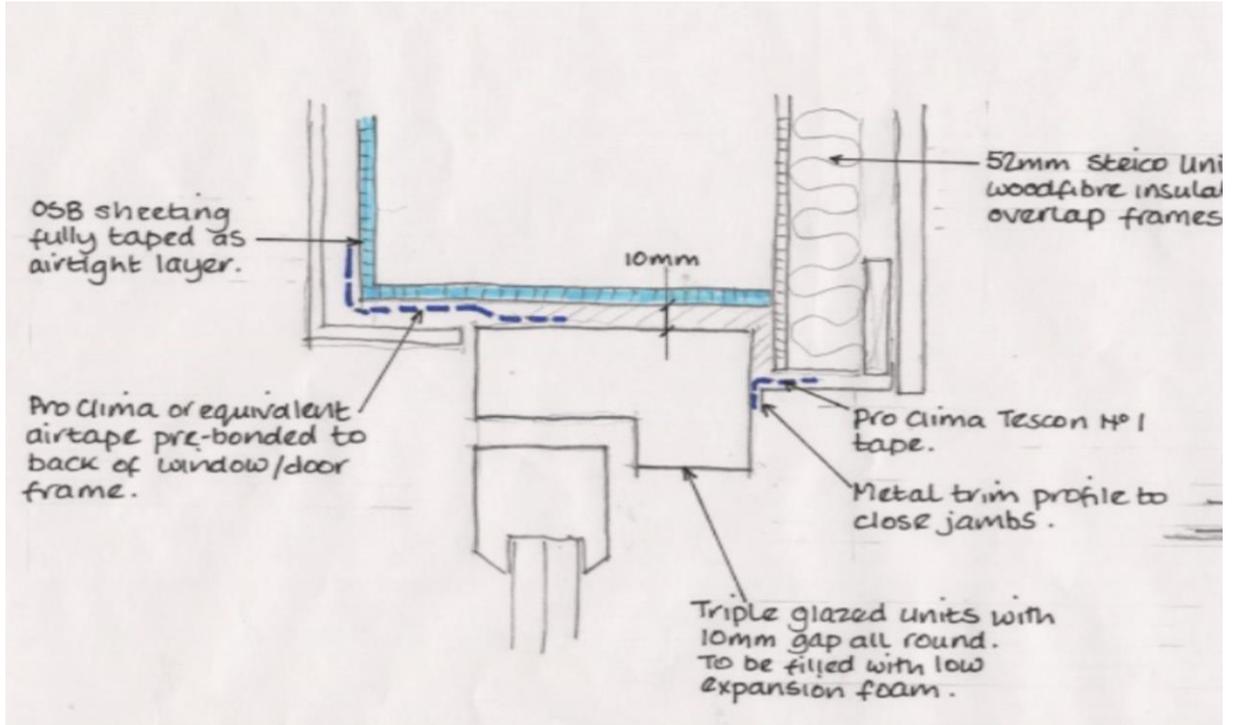
- 5.3.4 The verge detail at the junction of the roof and the gable end is shown below. This shows how the insulation continuity was achieved in both the injected glass fibre insulation and the external wood fibre insulation.



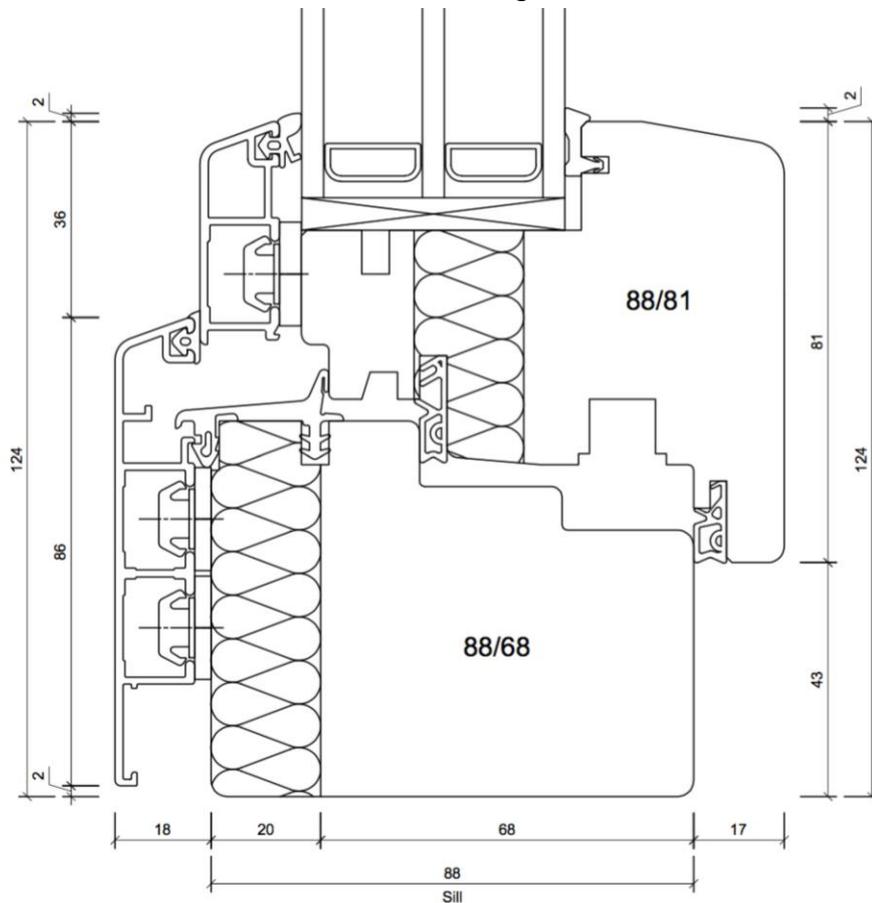
5.4 Windows

- 5.4.1 Windows were fitted flush with the exterior face of the timber structure, which allows the outer woodfibre board to slightly overlap the window and door frames. The gaps around the windows and doors has been designed at 11mm wide, which I have found to be ideal for injection with low expansion foam, which is trimmed flush before sealing with airtight tape.

5.4.2 Detail section through window jamb.



5.4.3 The window profile section shows the insulation layer incorporated into the frame and sash, and aluminium facing.



5.4.4 Manufacturers calculation for the Ug value:



Determination of glazing characteristics

The following characteristics are calculated with the program SILVERSTAR glACE

Version information:
 Program 3.10
 Database 3.07
 Output format 3.10

Project:

Company:

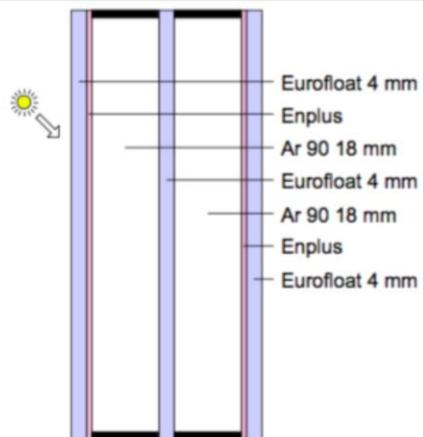
Employee:

Customer:

Product:

Date: 15.06.2012

Glazing:
 Window tilt angle: 90°



Comments:

Calculated glazing characteristics:

Thermal transmittance Ug:	0.528 W/m²K	EN673:2011	CE
Total solar energy transmittance (g-value):	49.29 %	EN410:2011	
Light transmittance:	70.42 %		
Light reflectance (outside):	18.21 %		
Light reflectance (inside):	18.21 %		
Light absorption:	11.37 %		
Solar direct transmittance:	41.75 %		
Solar direct reflectance (outside):	32.26 %		
Solar direct absorption:	25.99 %		
Secondary internal heat transfer Factor:	7.54 %		
UV-Transmittance:	16.58 %		
UV-Reflectance:	16.01 %		
UV-Absorption:	67.41 %		
General Color Rendering Index Ra (trans.):	96.42		
Selectivity (Lt / g-value):	1.429		
Shading Coefficient (g-value / 0.87):	56.66 %		
Shading Coefficient (g-value / 0.8):	61.61 %		

The data shown are calculated in compliance with European standards EN410:2011 and EN673:2011 and are based on certified data.
 Due to production tolerances as defined in applicable EN standards, small deviations of effective data are possible.
 National standards or surcharges (e.g. for U value) are not taken into account.

5.4.5 Manufacturers calculation for whole window U value, including Uf value for frame:



Berechnung des Wärmedurchgangskoeffizienten Uw (Ucw)

Bearbeiter: Herr Rönnebeck Datum: 07.01.2009
 Kunde: ARBO

Randbedingungen:	Kurz-Zeichen	Beschreibung	Werte	Einheit
System		Mira Therm	---	---
Abstandhalter:	Psi	Thermix	0,041	W/mK
Glas / Paneel:	Ug	Isolierglas	0,600	W/m²K
Rahmen:	Uf	Nadelholz / Alu	0,880	W/m²K
Fensterbreite:			1,500	m
Fensterhöhe:			1,500	m
Rahmenbreite:			0,123	m

Berechnung:

Gesamtfläche:	Ag + Af	2,250	m²
Glasfläche:	Ag	1,573	m²
Rahmenfläche:	Af	0,677	m²
Länge Glas- Abstandhalter	l	5,016	m
Wärmedurchgangskoeffizient Uw (Ucw):		0,776	W/m²K

zu Grunde liegende Berechnungsformel:

$$U_w = (A_g \cdot U_g + A_f \cdot U_f + l \cdot \Psi) / (A_g + A_f)$$

Bemerkung:

Unsere Beratung in Wort und Schrift beruht auf Erfahrung. Sie erfolgt nach bestem Wissen und gilt immer als unverbindlicher Hinweis. Aus diesen Berechnungen können keine Rechtsansprüche gegen uns abgeleitet werden.

6 The Airtight envelope

- 6.1 The first challenge was that the contractor had never built to an airtightness standard before. The details had to be simple to execute. The airtight junctions were drawn carefully, and airtight layers shown on the timber frame companies drawing.



- 6.2 Certain membranes had to be installed during the construction so that continuity could be ensured between each floor. The photograph above shows the membrane sandwiched under the ground floor structure. The principle is also shown in the drawing in 5.3.3.
- 6.3 The contractor chose to upgrade the vapour control layer to an aluminium foil faced material, a measure I would not normally recommend. However the membrane has a very good Sd value.
- 6.4 All ductwork and services were kept fully inside the airtight layer. Incoming services were not installed as recommended with a space between each duct/pipe, but grouped together. This proved more difficult to make airtight.
- 6.5 During construction of the concrete floor the DPM was left overlapping to allow connection to the internal vapour control layer/airtightness membrane, then covered with a protective sheet whilst the slab was polished. Regrettably the flooring contractor then sliced off the membrane flush with the top of the slab, leaving nothing projecting at all. The only solution was to take down some of the perimeter brickwork to expose the edge of the membrane, and extend the membrane using a high bond waterproof butyl tape.

- 6.6 Preliminary air testing showed that the contractor had left some areas to improve such as service entries, and corners where the airtight membrane was wrapped around the floor cassettes. The final results came in just about on target, 0.58 and 0.59 ach under pressurisation and depressurisation respectively. The test was carried out by JTec Environmental Ltd, Dorset, BINDT test ref 68104.
- 6.7 Copies of the pressurisation test and depressurisation test is attached from JTec Environmental Ltd.

BUILDING LEAKAGE TEST

JTEC Environmental Ltd
 Tansley Cottage, Shave Lane
 Todber
 Sturminster Newton, Dorset DT10 1JA
 Phone: 01258 821398
 Fax: 01258 821398

Date of Test: 7/11/13	Technician: J D Chilvers
Test File: The Den - Hartfoot Lane - Depressurization	
Customer: Mr D Merrigan The Den Hartfoot Lane Ansty Dorchester, Dorset DT2 7PN Phone: Fax:	Building Address: The Den Hartfoot Lane Ansty Dorchester, Dorset DT2 7PN

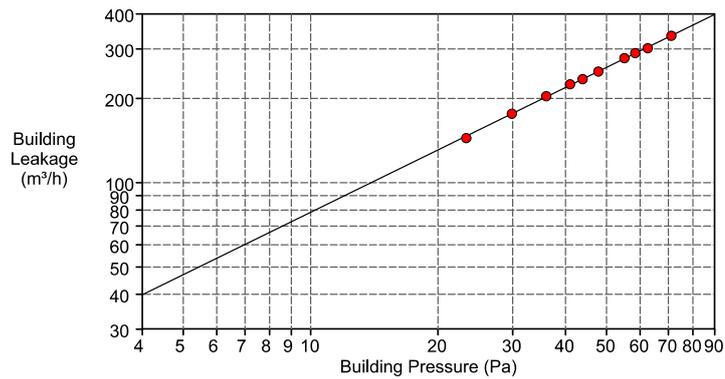
Airflow at 50 Pascals: 258 m³/h (+/- 0.2 %)
 (50 Pa = 0.2 w.c.) 0.59 ACH (1/h)

Leakage Areas: 87.5 cm² (+/- 1.1 %) Canadian EqLA @ 10 Pa
 42.8 cm² (+/- 1.8 %) LBL ELA @ 4 Pa

Building Leakage Curve: Flow Coefficient (C) = 14.3 (+/- 2.7 %)
 Exponent (n) = 0.740 (+/- 0.007)
 Correlation Coefficient = 0.99965

Test Standard: EN 13829	Test Mode: Depressurization	
Type of Test Method: B	Regulation complied with: ADL1A	
Equipment: Model 3 Minneapolis Blower Door, S/N 12455		

Inside Temperature: 16 °C	Volume: 440 m ³	
Outside Temperature: 11 °C	Surface Area:	
Barometric Pressure: 99330 Pa	Floor Area:	
Wind Class: 1 Light Air	Uncertainty of:	
Building Wind Exposure: Partly Exposed Building	Building Dimensions: 2 %	
Type of Heating: Heat recovery unit	Year of Construction: 2013	
Type of Air Conditioning: None		
Type of Ventilation: Natural		



BUILDING LEAKAGE TEST

JTEC Environmental Ltd
Tansley Cottage, Shave Lane
Todber
Sturminster Newton, Dorset DT10 1JA
Phone: 01258 821398
Fax: 01258 821398

Date of Test: 7/11/13	Technician: J D Chilvers
Test File: The Den - Hartfoot Lane - Pressurization	
Customer: D Merrigan The Den Hartfoot Lane Ansty Dorchester, Dorset DT2 7PN Phone: Fax:	Building Address: The Den Hartfoot Lane Ansty Dorchester, Dorset DT2 7PN

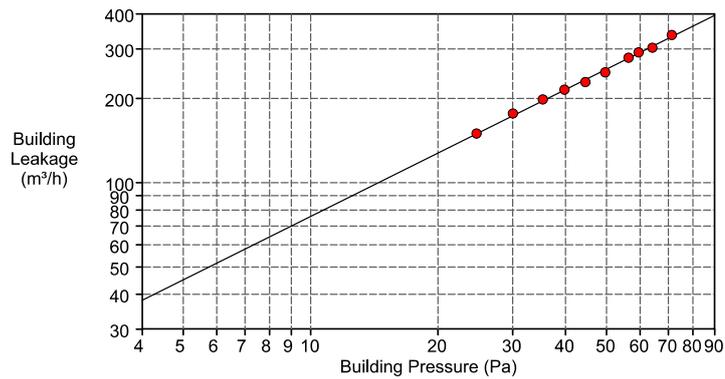
Airflow at 50 Pascals: 254 m³/h (+/- 0.5 %)
(50 Pa = 0.2 w.c.) 0.58 ACH (1/h)

Leakage Areas: 84.7 cm² (+/- 2.7 %) Canadian EqLA @ 10 Pa
41.1 cm² (+/- 4.1 %) LBL ELA @ 4 Pa

Building Leakage Curve: Flow Coefficient (C) = 13.5 (+/- 6.3 %)
Exponent (n) = 0.751 (+/- 0.016)
Correlation Coefficient = 0.99822

Test Standard:	EN 13829	Test Mode:	Pressurization
Type of Test Method:	B	Regulation complied with:	ADL1A
Equipment:	Model 3 Minneapolis Blower Door, S/N 12455		

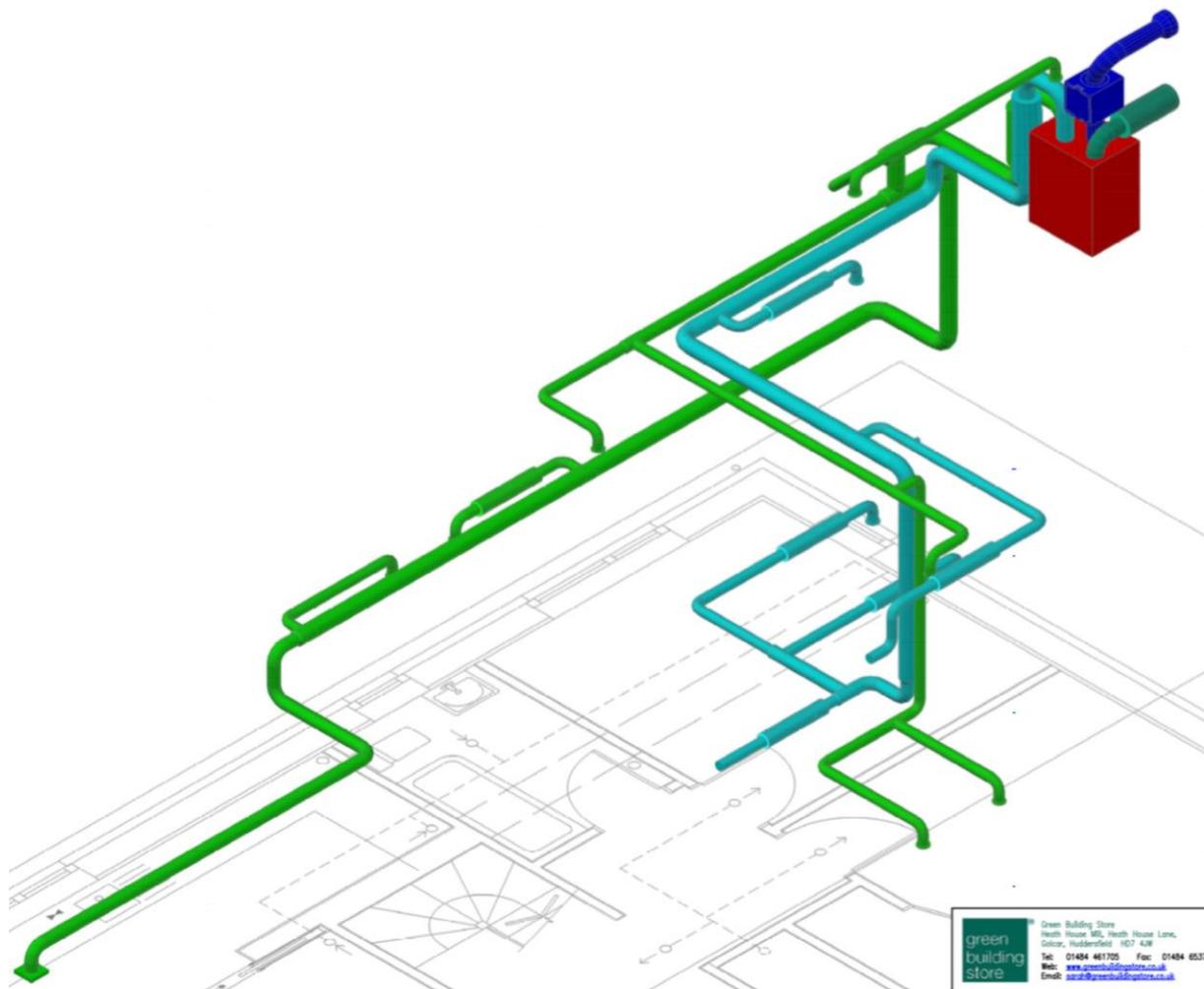
Inside Temperature: 16 °C	Volume: 440 m ³
Outside Temperature: 12 °C	Surface Area:
Barometric Pressure: 99960 Pa	Floor Area:
Wind Class: 1 Light Air	Uncertainty of:
Building Wind Exposure: Partly Exposed Building	Building Dimensions: 2 %
Type of Heating: Heat recovery unit	Year of Construction: 2013
Type of Air Conditioning: None	
Type of Ventilation: Natural	



7 Mechanical system

7.1 Ventilation ductwork

7.1.1 The MVHR intake is at second floor level on the east elevation directly in to the plant room. Ductwork is mostly run through the I joist floors, but at second floor level it runs in the low level space at the eaves. Fresh air supply to each bedroom and living space, and extract from bathroom, kitchen, ensuites and utility room. The routing proved to be quite complex, even though much work was done to keep it simple and short.



7.1.2 Rigid galvanised steel circular duct was used with ready made joints containing an EPDM gasket. Although this material is expensive it allows for very good quality installations by skilled carpenters, without needing to use specialist duct installers. Some joists needed to be reinforced where large diameter ducts were run, exceeding the cut out limits for the joist. Ducts were kept taped closed during construction to keep them clean.

- 7.1.3 Joist reinforced to accept large diameter duct. Duct taped closed to keep out dust.



- 7.1.4 Silencers were used to prevent noise from the MVHR unit and prevent cross talk. Some ducts needed to be installed at a very early stage in the build to allow them to be fitted through the joists, as shown in photo above.

7.2 Ventilation unit

- 7.2.1 A Paul Novus 300F unit was located in the top floor plant room on the external wall. It was a tight fit, as the ceiling height is limited and the unit is very large. However, it is easy to access for cleaning the filters and maintenance. The contractor did a very neat job of insulating the exterior ducts with closed cell foam and taping the joints, not an easy task.

- 7.2.2 The unit has a heat recovery rate of 93%, and a SFP of $0.23\text{W}/\text{m}^3\text{h}$ at $200\text{m}^3/\text{h}$. The system efficiency is 89%.³

- 7.2.3 As the inlet and outlet are at high level, pitot tubes were specified to allow balancing of the system.

- 7.2.4 Having stayed in the premises for 2 nights I can confirm the system is very quiet even on full speed.

- 7.2.5 The MVHR unit in the plant room

³ System efficiency added 18th Feb 2017



8 Heating

- 8.1 Heating was evaluated at great length. As with most rural houses there was no mains gas supply, leaving wood, electricity, or bottled gas as options. Ground source and air sourced heat pumps were considered, but the cost relative to the heat load were ridiculously expensive. A small condensing gas boiler was considered, running on propane, this would have quite simple, but the boilers available are either much too large or very expensive.
- 8.2 Underfloor heating was considered for the ground floor, but excluded as an unnecessary expense.
- 8.3 A small efficient wood stove was finally agreed upon for the main source of heating on the first floor, which being partly open to the second floor would heat both spaces. A 4kW 'Fox' unit by Woodwarm was chosen. In each bathroom, WC and ensuite an electric towel rail is provided, allowing timed

heating of each room, however, at the time of writing, these have not been connected to the electricity supply as they have not been needed.



4kW Woodwarm Fox stove.

- 8.4 It was decided to include solar thermal panels for hot water and PV panels to contribute to electricity demand, so as to reduce electricity demand, which backs up the hot water requirement. The panels are supplied by Fakro, who also supplied the Rooflights, so the units have matching finishes and flashings.
- 8.5 PV has a declared capacity of 2.42kW, annual estimated generation of 1940kWh.

8.6 Solar thermal has a declared capacity of 3kW, annual estimated generation of 1469kWh. The panels are connected to a Telford Tempest cylinder of 250 litres, with 75mm PU foam insulation.

9 PHPP results

9.1 Copy of Verification page. My client, Dennis Merrigan has consented to publication of these details.

Passive House Verification



Building:	The Den		
Location and Climate:	Dorset	4 South England	
Street:	Hartfoot Lane		
Postcode/City:	DT2 7PN	Anstey	
Country:	UK		
Building Type:	Detached House		
Home Owner(s) / Client(s):	Dennis Merrigan		
Street:	The Den, Hartfoot Lane		
Postcode/City:	DT2 7PN	Anstey	
Architect:	Conker Conservation Ltd		
Street:	6, The Stour Centre, 2-24 Stour Street		
Postcode/City:	CT1 2NZ	Canterbury	
Mechanical System:	Green Building Store		
Street:	Heath House Mill, Heath House Lane, Golcar		
Postcode/City:	BD7 4JW	Huddersfield	
Year of Construction:	2014		
Number of Dwelling Units:	1	Interior Temperature:	20.0 °C
Enclosed Volume V_e :	528.2 m ³	Internal Heat Gains:	2.1 W/m ²
Number of Occupants:	4.6		

Specific Demands with Reference to the Treated Floor Area					
	Treated Floor Area:	Applied:	Monthly method	PH Certificate:	Fulfilled?
Specific Space Heating Demand:	161.4 m ²	11	kWh/(m ² a)	15 kWh/(m ² a)	Yes
Heating Load:		11	W/m ²	10 W/m ²	
Pressurization Test Result:		0.6	h ⁻¹	0.6 h ⁻¹	Yes
Specific Primary Energy Demand (DHW, Heating, Cooling, Auxiliary and Household Electricity):		120	kWh/(m ² a)	120 kWh/(m ² a)	Yes
Specific Primary Energy Demand (DHW, Heating and Auxiliary Electricity):		89	kWh/(m ² a)		
Frequency of Overheating:		2	%	over 25 °C	
Cooling Load:		5	W/m ²		

10 Construction costs

- 10.1 Total construction cost based on gross external floor area £1467/m², inclusive of drainage, septic tank, ground works, paving, and design fees.
- 10.2 Construction cost as above based on cost per m² TFA £1763/m².
- 10.3 Building only construction cost based on gross external floor area excluding drainage, septic tank, ground works, £1426/m².

11 User experiences

- 11.1 Nicola and Dennis Merrigan kept a blog during the construction and completion of the house and regularly tweeted about their experiences. They faced a major challenge in the construction phase, when the timber frame manufacturer went into administration shortly before delivering the timber frame to site. This caused a major delay in the project and a huge cost increase in order to obtain the completed frame from the administrator.
- 11.2 This experience has not dampened their enthusiasm or enjoyment of the house. Temperatures in the house are very even, although the ground floor is 1.0-1.5 degrees cooler than the floor above due to the thermal mass of the concrete floor. In the summer they find this advantageous.
- 11.3 Overheating has not been a problem, but using the Rooflights and tilt and turn windows for stack ventilation. Heating is provided solely by the woodstove so far. Air quality has been reported as excellent at all times.
- 11.4 Dennis Merrigan is a quantity surveyor, running a firm of building contractors, he now hopes to get more involved in constructing passivhaus buildings professionally.