Project Documentation

1 Abstract

Refurbishment of an 1850 Victorian detached house on Dartmoor, Devon (UK)

1.1 Building data

Year of construction/ Baujahr	2011 (1850)	**Space heating / Heizwärmebedarf**	**30** **kWh/(m^{2}a)**
U-value external wall/ U-Wert Außenwand	0.178 W/(m^{2}K) (avg)		
U-value basement ceiling/ U-Wert Kellerdecke	0.223 W/(m^{2}K) (avg)	**Primary Energy Renewable (PER) / Erneuerbare Primärenergie (PER)**	-
U-value roof/ U-Wert Dach	0.067 W/(m^{2}K) (avg)	**Generation of renewable energy / Erzeugung erneuerb. Energie**	-
U-value window/ U-Wert Fenster	1.01 W/(m^{2}K)	**Non-renewable Primary Energy (PE) / Nicht erneuerbare Primärenergie (PE)**	104 kWh/(m^{2}a)
Heat recovery/ Wärmerückgewinnung	83.1 %	Pressure test n_{50} / Drucktest n_{50}	0.74 h-1
Special features/ Besonderheiten	Solar thermal collectors for hot water generation, Log burners for space heating		

1.2 Brief Description

House W - Refurbishment of an 1850 Victorian detached house on Dartmoor, Devon (UK)

The project was the refurbishment and deep energy retrofit of a 1850 Victorian detached house within the Dartmoor National Park in Devon, UK. The Victorian detached country house located on Dartmoor underwent a complete refurbishment and energy efficiency upgrade. Because of its location within a national park strict regulations regarding any changes to the exterior appearance applied. The stone walls had to remain unchanged and windows had to resemble the original ones. All existing exterior walls were therefore insulated and made air tight internally, windows replaced and a new MVHR system was installed. Because of its location and orientation and limitations to changes of the external appearance available solar gains were very limited.
Still a holistic passive design strategy allowed for the existing property to be upgraded to a level of energy efficiency such that a conventional heating system will only be required in times of extreme winter conditions.

The project was phased into two stages – phase 1 included the refurbishment and energy retrofit of the existing building which comprised a two storey solid stone masonry construction and a 1960s extension with cavity wall construction; in phase 2 a new two storey extension was added to the South with a new living room on ground floor and master bedroom with ensuite and dressing room on the first floor. Both phases were completed in 2011 and have since been occupied.

The completed building was certified as a PHI Low Energy building in 2015.

1.3 Responsible project participants

Architect/ Entwurfsverfasser	Gale & Snowden Architects Ltd (www.ecodesign.co.uk)
Implementation planning/ Ausführungsplanung	Gale & Snowden Architects Ltd (www.ecodesign.co.uk)
Building systems/ Haustechnik	Gale & Snowden Architects Ltd (Performance duties with contractor design) (www.ecodesign.co.uk)
Structural engineering/ Baustatik	Barry Honeysett Engineers, Exeter, Devon, UK
Building physics/ Bauphysik	Gale & Snowden Architects Ltd (www.ecodesign.co.uk)
Passive House project planning/ Passivhaus-Projektierung	Gale & Snowden Architects Ltd (www.ecodesign.co.uk)
Main contractor	Building Devon (www.buildingdevon.co.uk)

Certifying body/ Zertifizierungsstelle	Andrew Peel Peel consulting		
Certification ID/ Zertifizierungs ID	12129_APC_ LEB_20151102 _AP	Project-ID (www.passivehouse-database.org) Projekt-ID (www.passivehouse-database .org)	5310

Author of project documentation / Verfasser der Gebäude-Dokumentation	Tomas Gaertner Gale & Snowden Architects Ltd
Date, Signature/ Datum, Unterschrift	15th June 2017

2 Views

View from North: Dartmoor National Park planning policy required that the external appearance had to remain unchanged. To maintain all granite stonework walls were insulated internaly.

View from East showing the existing building and the new extention (rendered façade on the left).

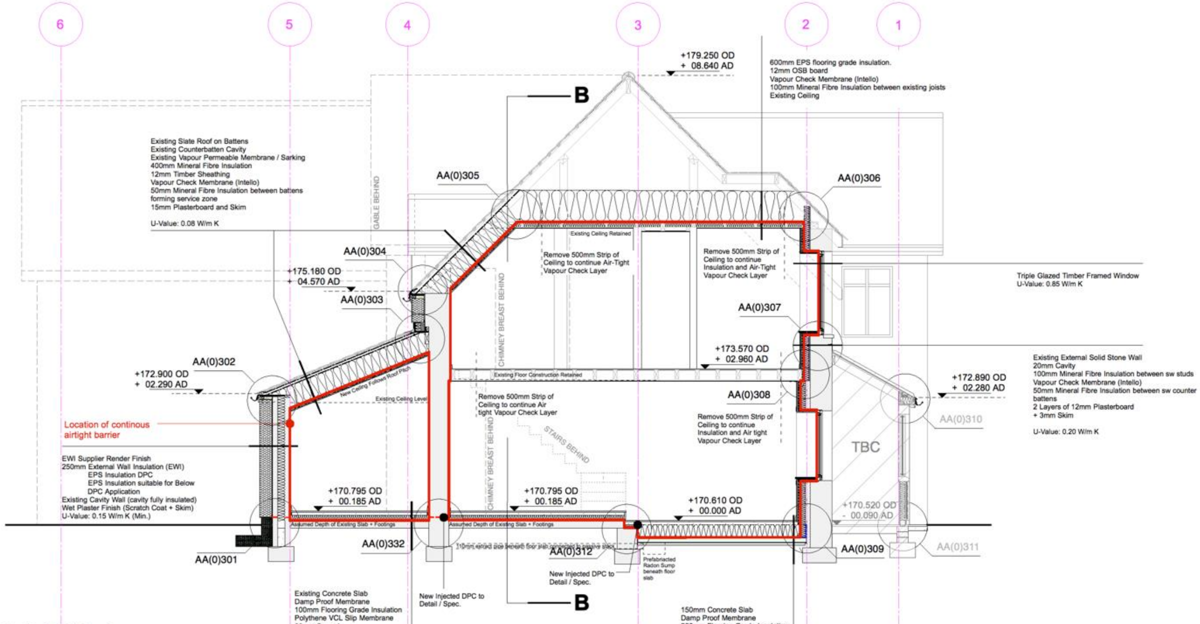
View from South East with the new two storey extension in the front.

View from South with Dartmoor and Castle Drogo in the background

View from West; the 1960s single storey extension can be seen in the front right corner.

Kitchen/dining and air tight range cooker with backboiler option replicating a traditional feature.

3 Section



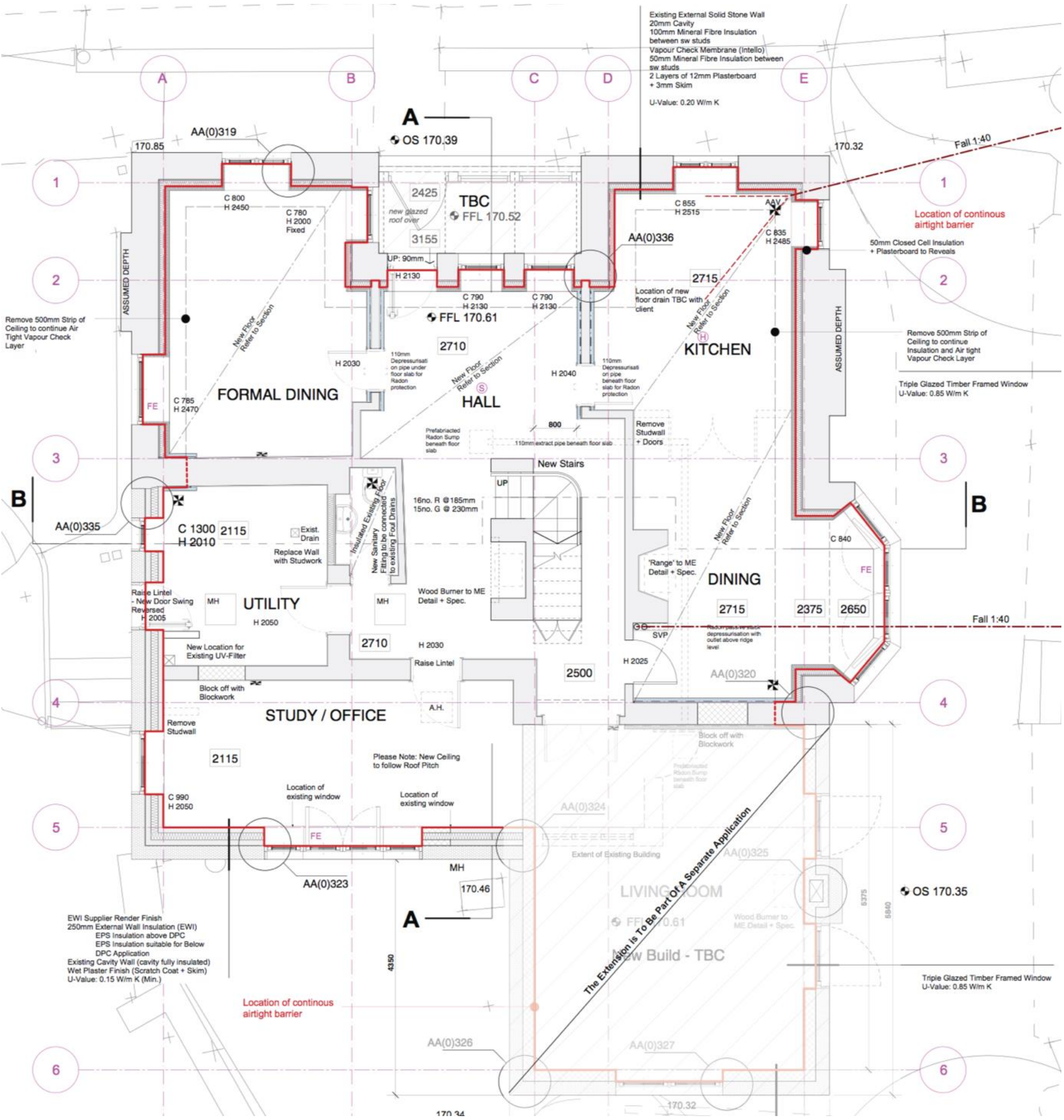
SECTION A - A
Scale 1:50

Cross Section showing the original two storey solid stonework masonry construction dating back to 1850 on the right (North) and a single storey 1960 extension with cavity wall construction tot he left (South).

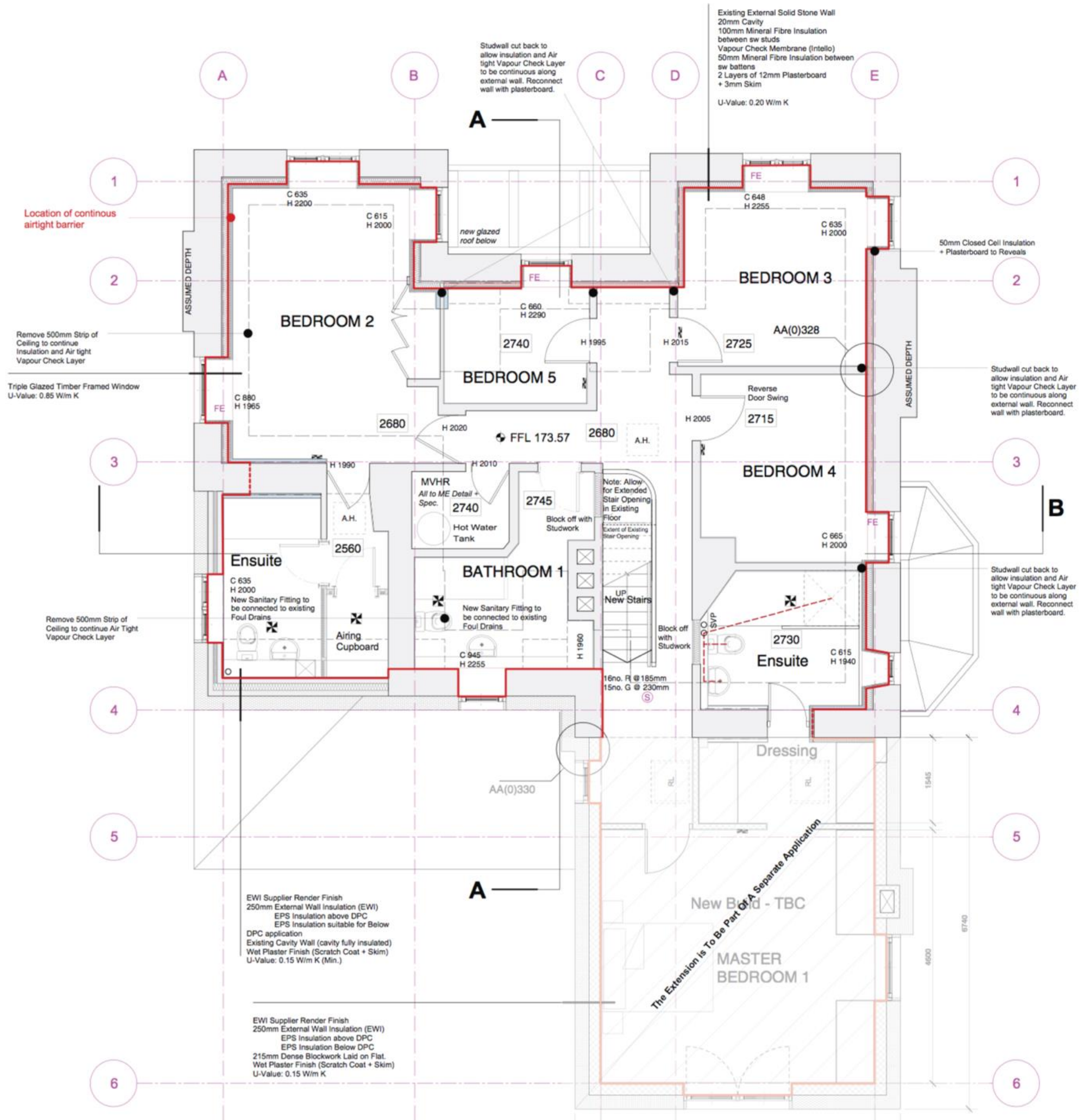
All stonework masonry elements were insulated internally using a timeber studwork construction with infill insulation. The rendered rear facade received an external wall insulation system. Internal finishes of the roof were removed and ceilings lowered to allow for significant improvements to insulation levels to make good for additional heat losses relating to thermal bridges etc from the existing structure. The 1960s part of the building had 100mm of EPS floor insulation and this floor was retained for economic reasons. The original house had a suspened timber floor which was replaced by a groundbearing slab with insulation and screed over. All windows were replaced by timber framed triple glazed units to match the existing. The air tighness layer within the roof and internal wall insulation system was formed by a flexible VCL membrane. At internal masonry junction details and where external wall insulation was applied to the rear the plaster layer formed the air tightness. The existing intermediate floor was cut back by 500mm to continue the air tightness membrane up and around floor joists using specialist air tight tapes.

A Passivhaus certified whole house ventilation system was located in a plant room on the first floor with intake and exhaust above roof to ensure short cold duct runs. Supply and extract ducts are located within the ceiling void using Zehnder comfotube flexible duct system.

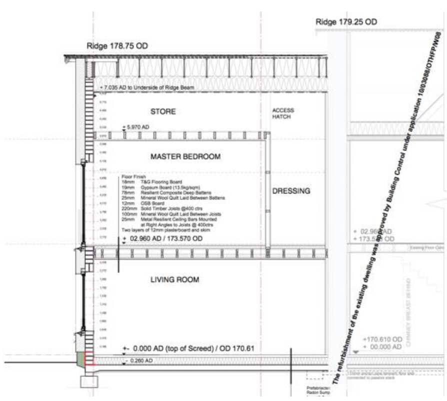
4 Floor plans

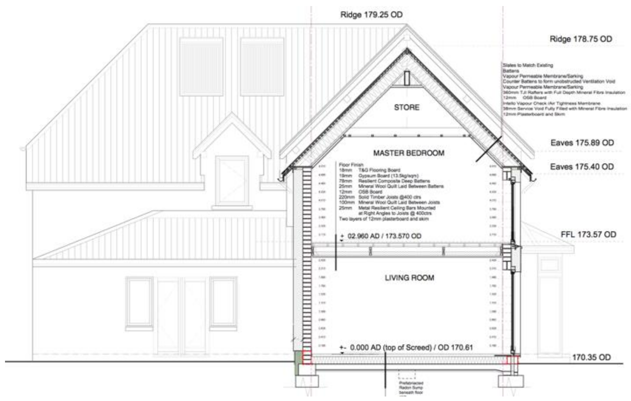


Ground floor plan with the new extension on the South greyed in (please see separate drawings further down below). The original Victorian house included the areas that are now the formal dining, hall, stairs, kitchen and dining; in the 1960s a single storey extension was added where now the utility and stufy/office is located. As part of this project a new two storey extension was added to the South.



First floor plan: bedrooms, family bathroom 1 and plant room are located within the original 1850s Victorian part; the ensuite to bedroom 2 is located within the 1960s cavity wall extension. A new master bedroom with dressing room and ensuite was added to the South as part of phase 2 of this project (bottom right). Please see below sections of the new extension.

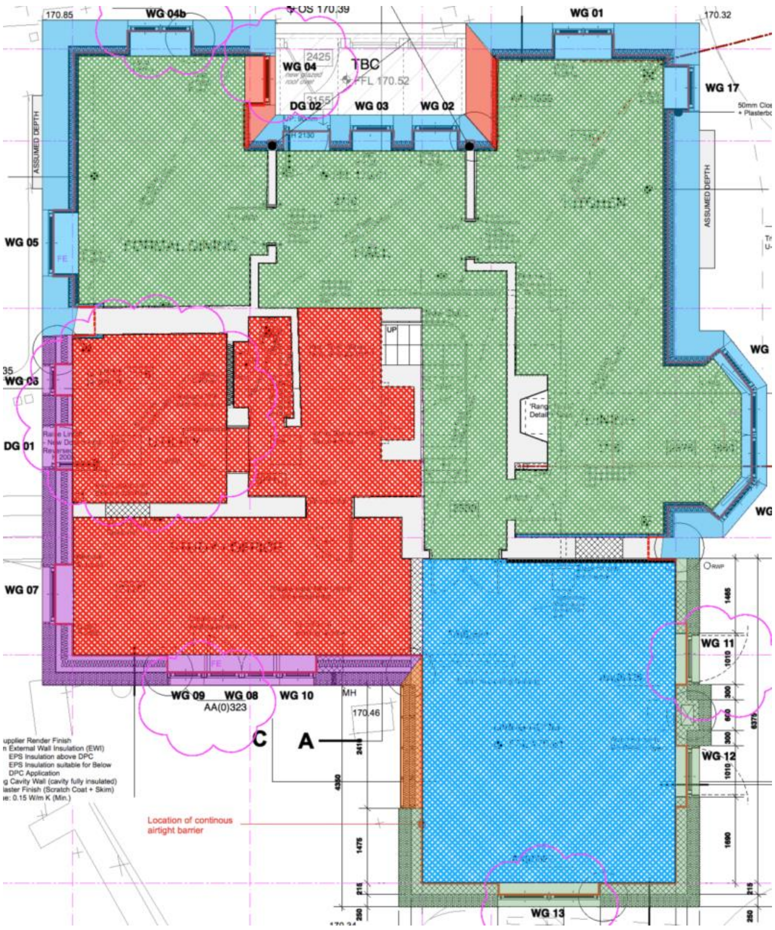


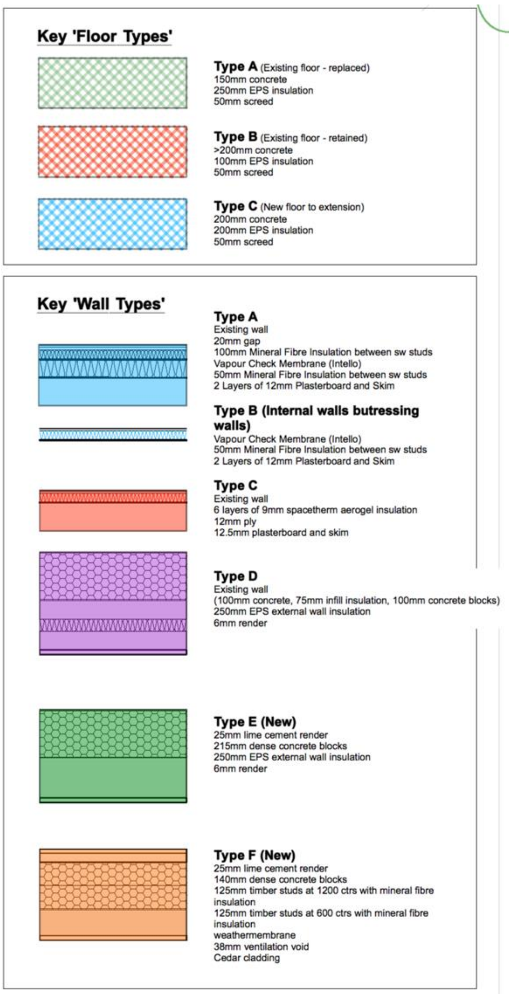


5 Building fabric construction details and Passivhaus technology

The refurbishment and energy retrofit for this project required a range of different wall and floor constructions because of planning restrictions, existing constructions and existing materials. Local planning policies required for the stone masonry walls to be left exposed and so internal wall insulation was required. Rear facades and areas that were rendered offered the opportunity to apply insulation externally and thus save space. During the build the client raised concerns about the loss of space due to the internal wall insulation and an alternative internal wall insulation with a higher performing insulant (aerogel) was specified where it helped to maintain more useful spaces. Below marked up drawings show the areas of the different wall and floor constructions and their respective build ups.

5.1 Floor types





Ground floor plan showing diffrent floor and wall types

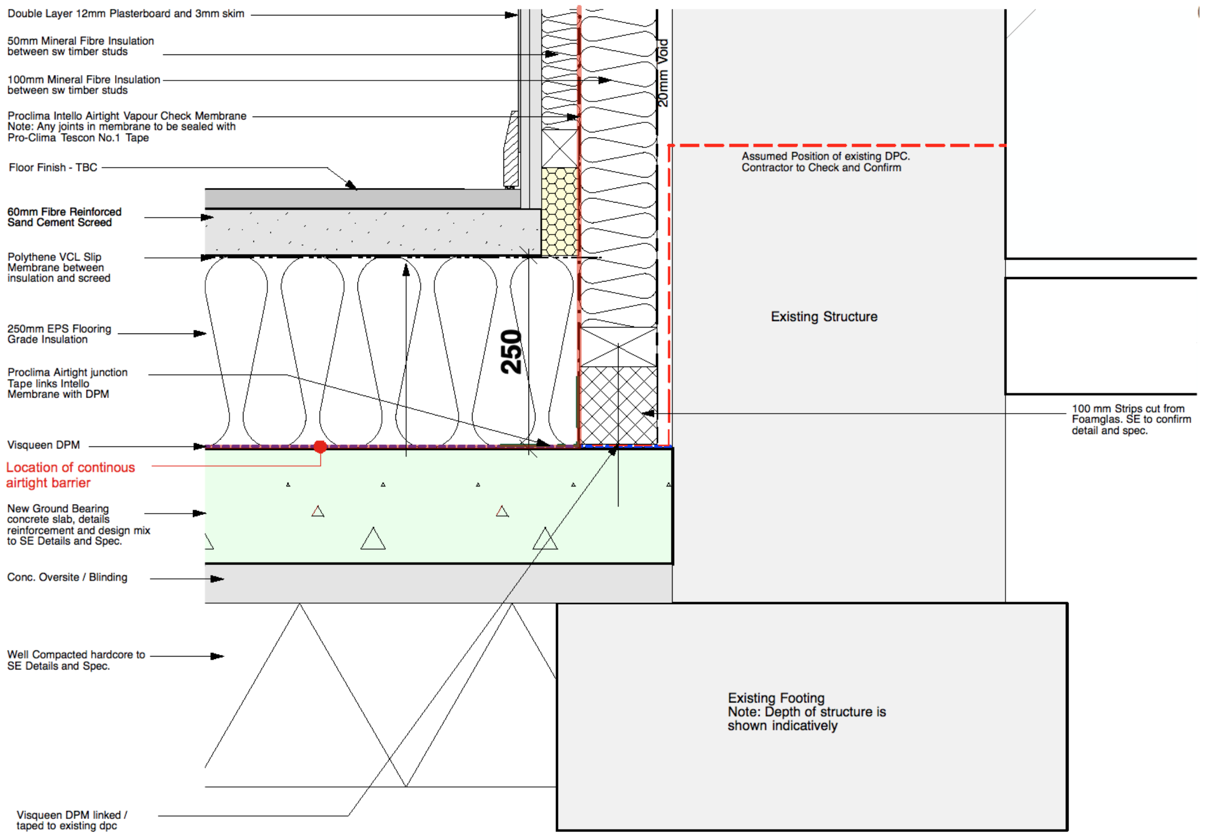
<u>Floor types</u>

Three different floor constructions were used on this project: Floor Type A (green) is a replacement floor for the original 1850s Victorian part of the house; Floor type B (red) is an existing floor from the 1960s which already had 100mm of EPS insulation and which was retained; Floor type C (blue) is the new floor to the new extension constructed under phase 2 of this project.

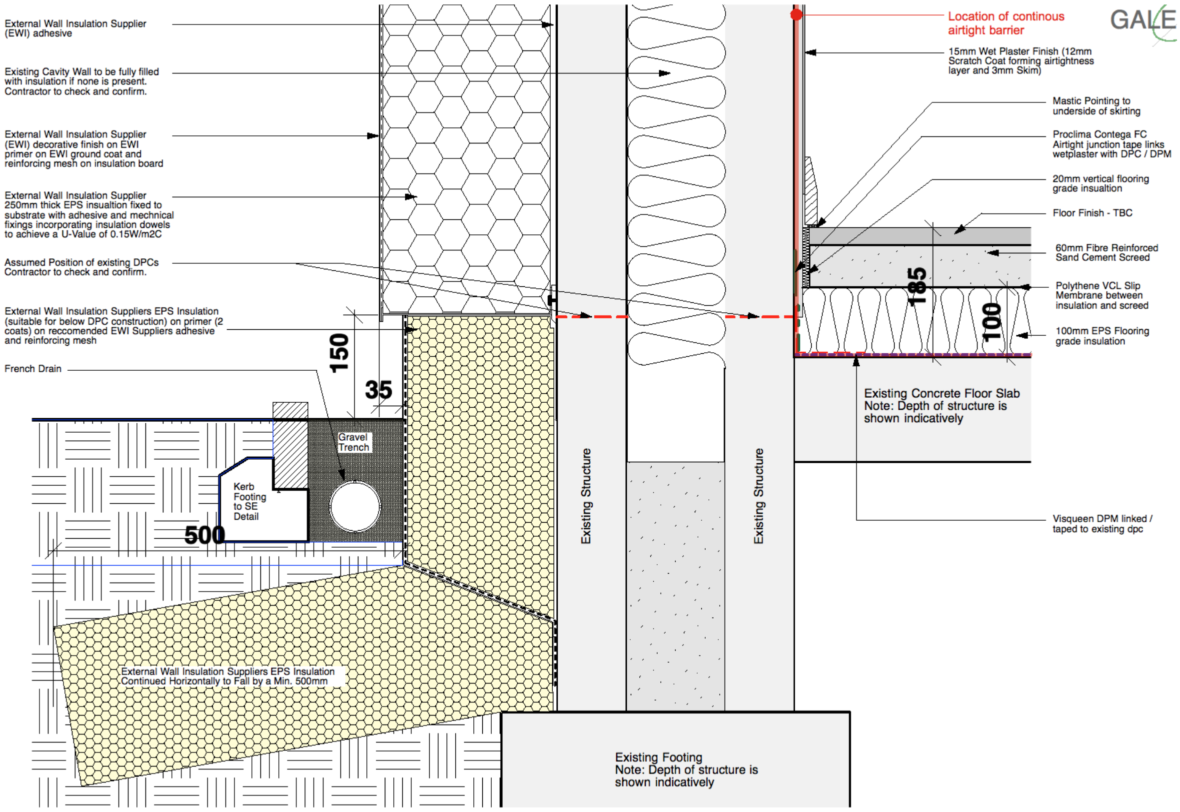
U values

Type	Internal/external	Location	U-value	Average U-value
Floor Type A	na	Original 1850s floor	0.138 W/m2K	0.223 W/m2K
Floor Type B	na	Original 1960s floor	0.432 W/m2K	
Floor Type C	na	New extension	0.170 W/m2K	

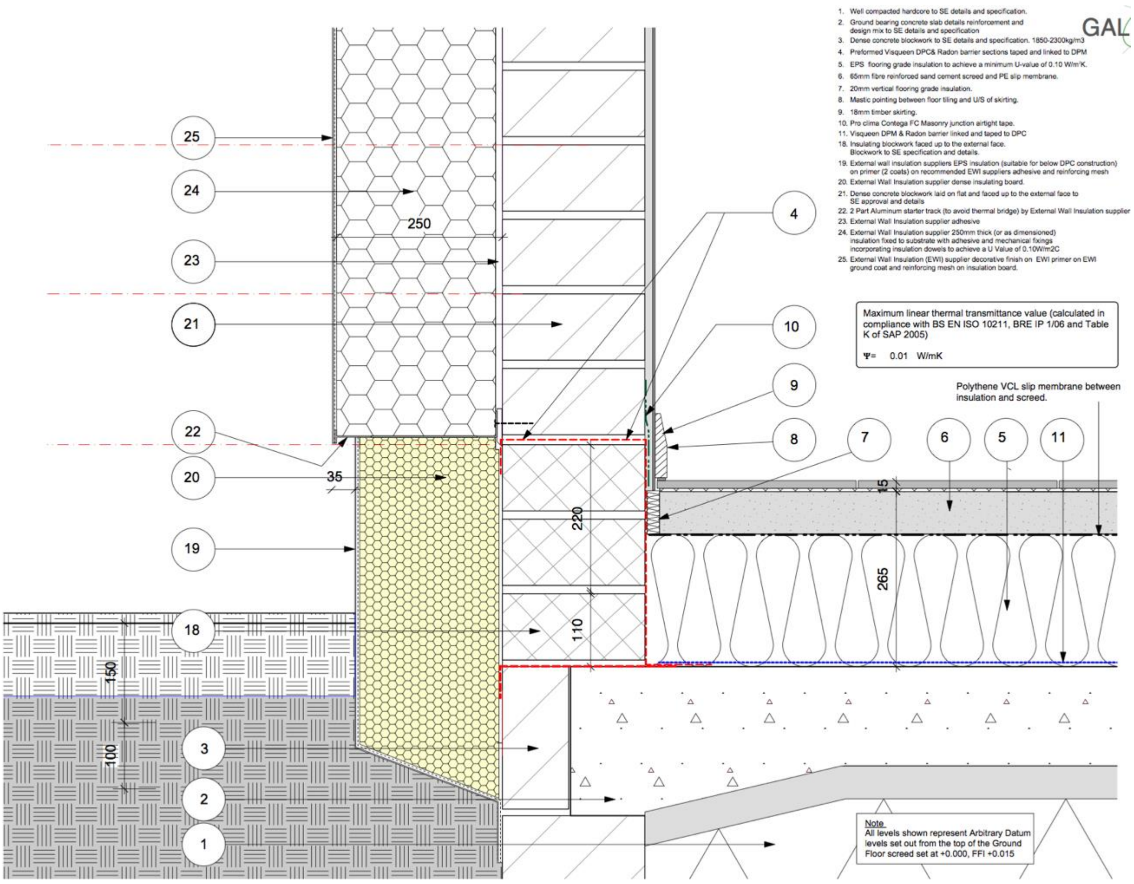
Floor construction details



Floor type A: Ground floor junction (with wall type A)

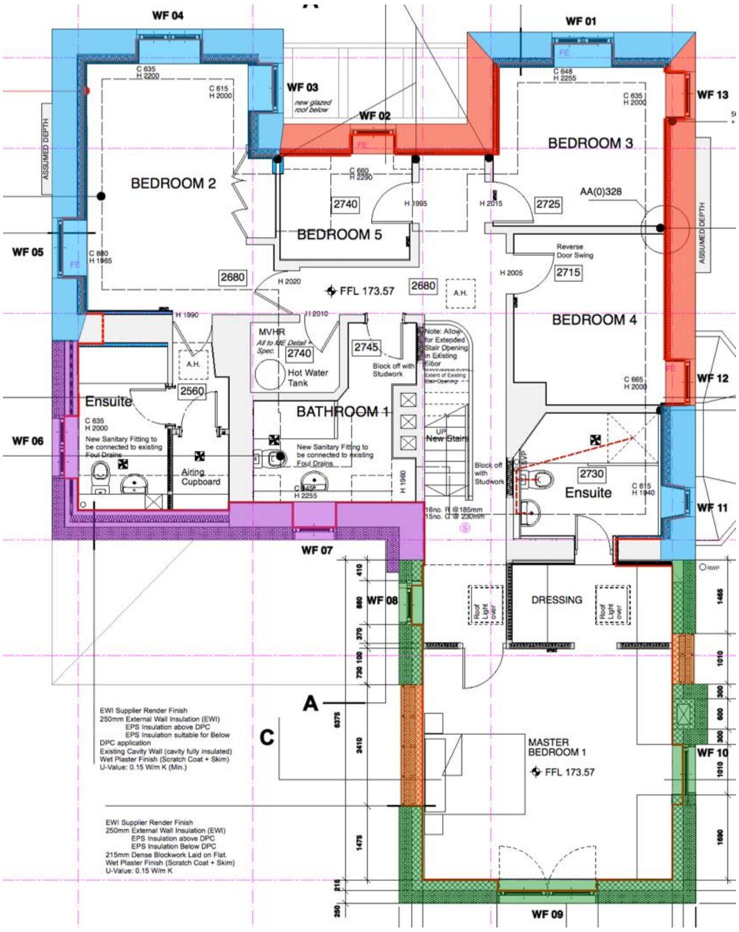


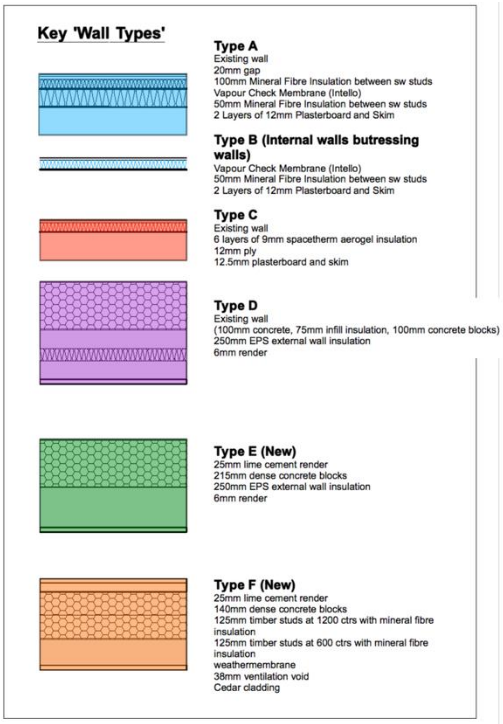
Floor type B: Ground floor junction (with wall type D)



Floor type C: Ground floor junction (with wall type E)

5.2 Wall types





First floor plan showing different wall types

<u>Wall types</u>

Five different wall types were used on this project: Wall type A (blue) was an internal wall insulation developed for existing solid masonry walls (used to retrofit the 1850s Victorian walls); wall type C (red) was a ‚space saving' internal wall insulation for solid masonry walls using aerogel insulation (again, used to retrofit the 1850s Victorian walls where space was tight); wall type D was an external wall insulation over existing fully filled cavity wall construction (used to clad the 1960s extension); wall type D was an external wall insulation with render finish over new solid blockwork walls (used for the new extension); wall type F was an external wall insulation with timber cladding over new solid blockwork walls (used for the new extension; the planning authority required a change of material to visually break down the rendered areas).

<u>U values</u>

Type	Internal/external	Location	U-value	Average U-value
Wall Type A	Internal	1850s solid stone walls	0.224 W/m2K	0.178 W/m2K
Wall Type C	Internal	1850s solid stone walls	0.215 W/m2K	
Wall Type D	External	1960s cavity walls	0.109 W/m2K	
Wall Type E	External	New extension	0.130 W/m2K	
Wall Type F	External	New extension	0.137 W/m2K	

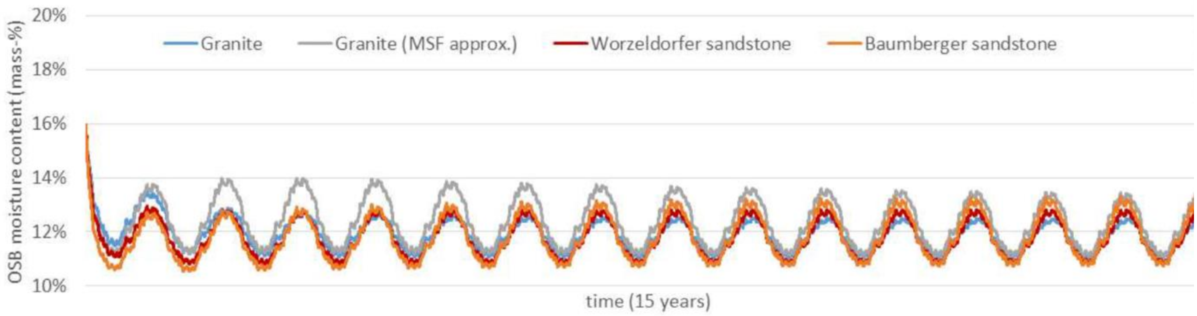
Hygrothermal assessment

A hygrothermal numerical simulation to BS EN 15026:2007 was carried out for the internal wall insulation details (ie wall type A and wall type C) by ‚Building Life Consultancy Ltd.' Using WUFI software.

This dynamic simulation takes into account the inter-related effects of heat, liquid water and water vapour moving through components over any length of time with inputs and outputs taken (usually) every hour, where boundary conditions (such as external weather) vary.

Unlike the more common Glaser method, a transient hygrothermal simulation is also suitable to assess properties of hygroscopic, capillary active and porous building materials.

For this project it was used to assess the risk of interstitial condensation, moisture build up and mould risk, over a period of 15 years.



Analysis of moisture content of OSB in wall type C shows that moisture content is kept well below 20 mass-percent at all times for all assessed build ups

The assessment using the outputs of WUFI Pro hygrothermal simulation concluded:

- Wall build-up A appears to be more vulnerable than build-up C to the particular moisture absorption and storage characteristics of the original stone wall.
- Both proposed build-ups appeared to be acceptable, within the range of conditions assessed.

Wall construction details

Wall type D: showing installation of EIFS

Wall type E/F: showing ‚aerated block warm' foot detail

Wall type E/F: showing installation of EIFS

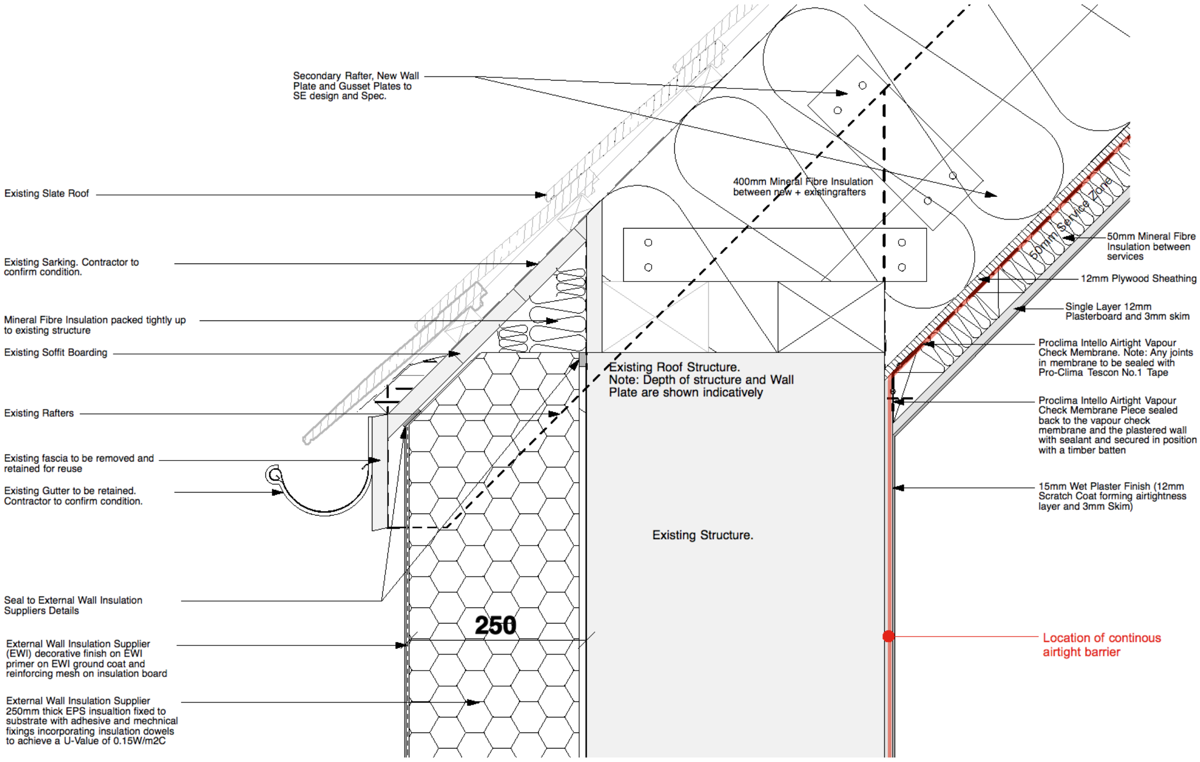
Wall type A: showing foamglass warm foot detail

Wall type A: showing VCL and service void

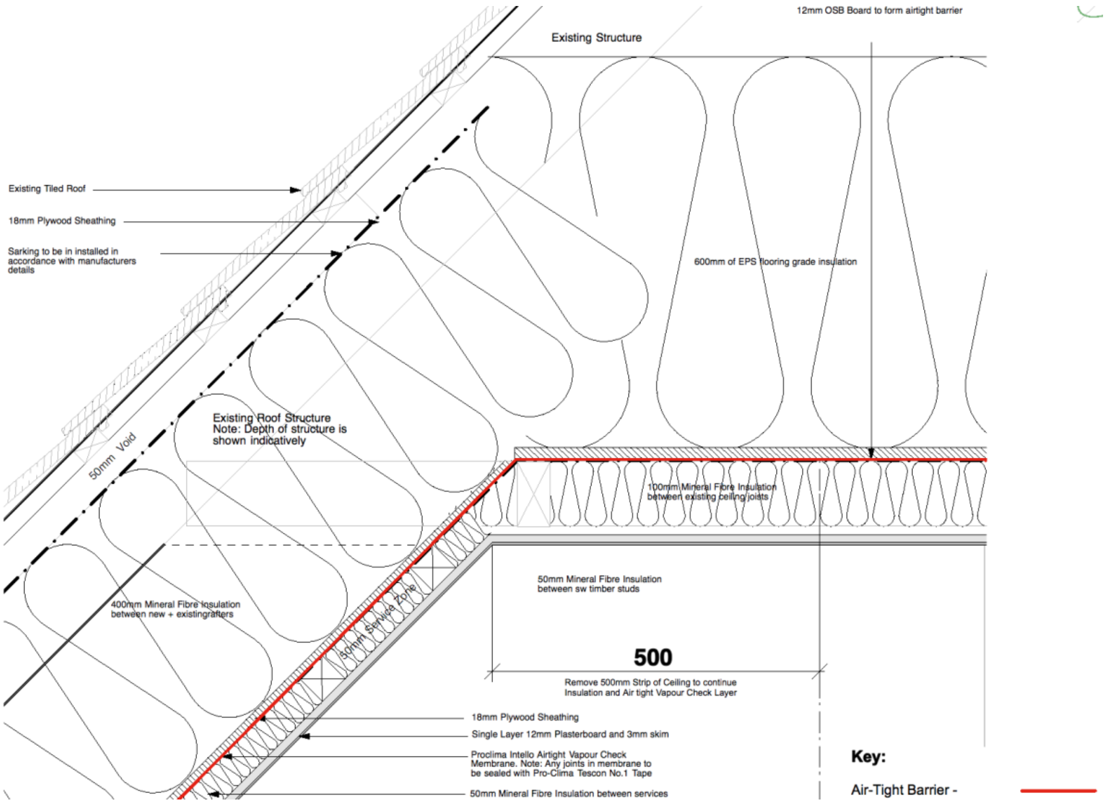
Wall type A: finished wall in kitchen

Wall type C: Aerogel insulation wall lining

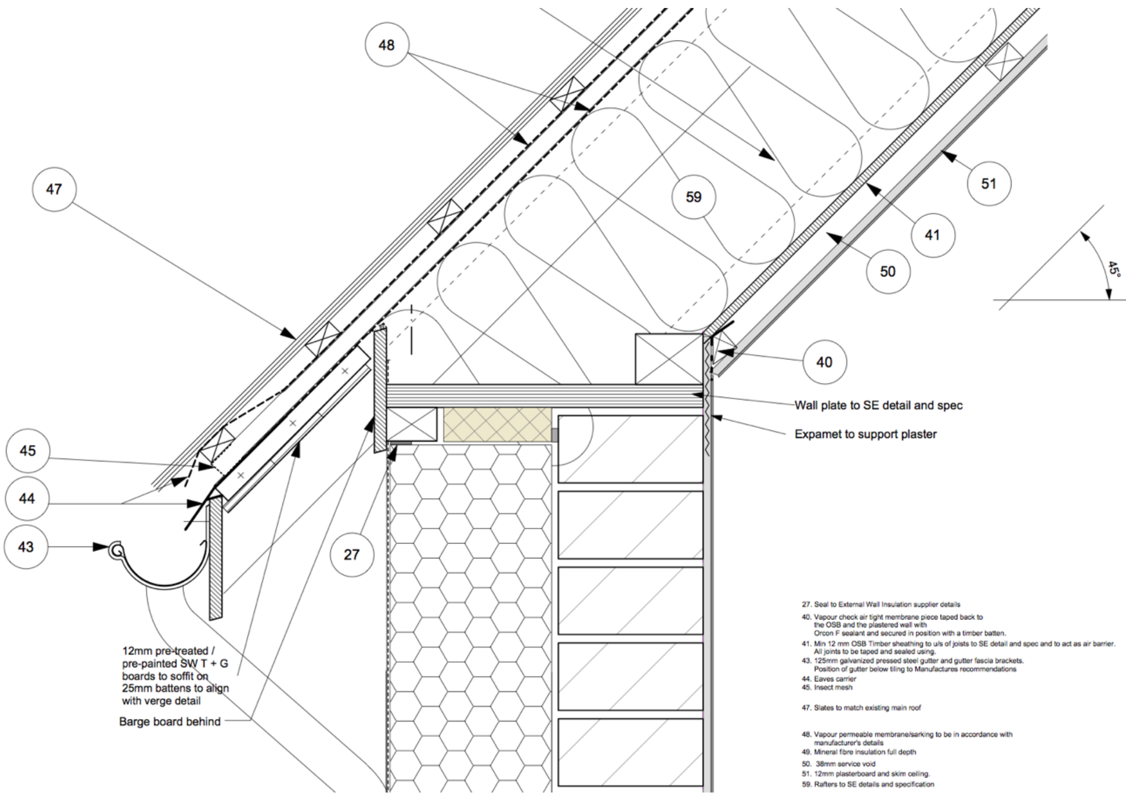
5.3 Roof/ceiling Construction



Work to existing roof: On all sloping roofs the existing rafters were exposed and doubled up using gusset plates to create Larsen trusses allowing for a minimum of 400mm of mineral fibre insulation with 12mm plywood sheathing and VCL to act as air barrier. A final 50mm insulation filled service void was installed.



Work to existing roof: Horizontal ceilings were exposed and an OSB board was laid over existing joists to act as air barrier with 600mm of rigid insulation over. Void between ceiling joists was fully filled with fibre insulation and plasterboarded.



New roof of extension: ventilated warm roof; 365 TJI rafter fully filled with fibre insulation, 12mm OSB (air barrier) with 50mm insulation filled service void and plasterboard.

U values

Type	Location	U-value	Average U-value
Roof Type A	Existing sloping	0.086 W/m2K	0.066 W/m2K
Roof Type B	Existing horizontal	0.051 W/m2K	
Roof Type C	New extension	0.081 W/m2K	

Roof construction details

Insulation to existing roof:
Rigid EPS insulation was tightly fitted any penetrations. Any remaining gaps were packed with mineral fibre insulation.

Rigid insulation fitted to existing roof.

5.4 Windows

Devon is located in the 'warm temperate' PH climate zone and the temperatures are generally fairly mild. Higher Uw-installed are acceptable than in a central European climate. According to PHPP 9.6 the minimum requirements are as follows ("windows" worksheet) for this area:

Recommendation for $U_{W,installed}$ [W/(m²K)]			
1.05	1.10	1.20	0.65

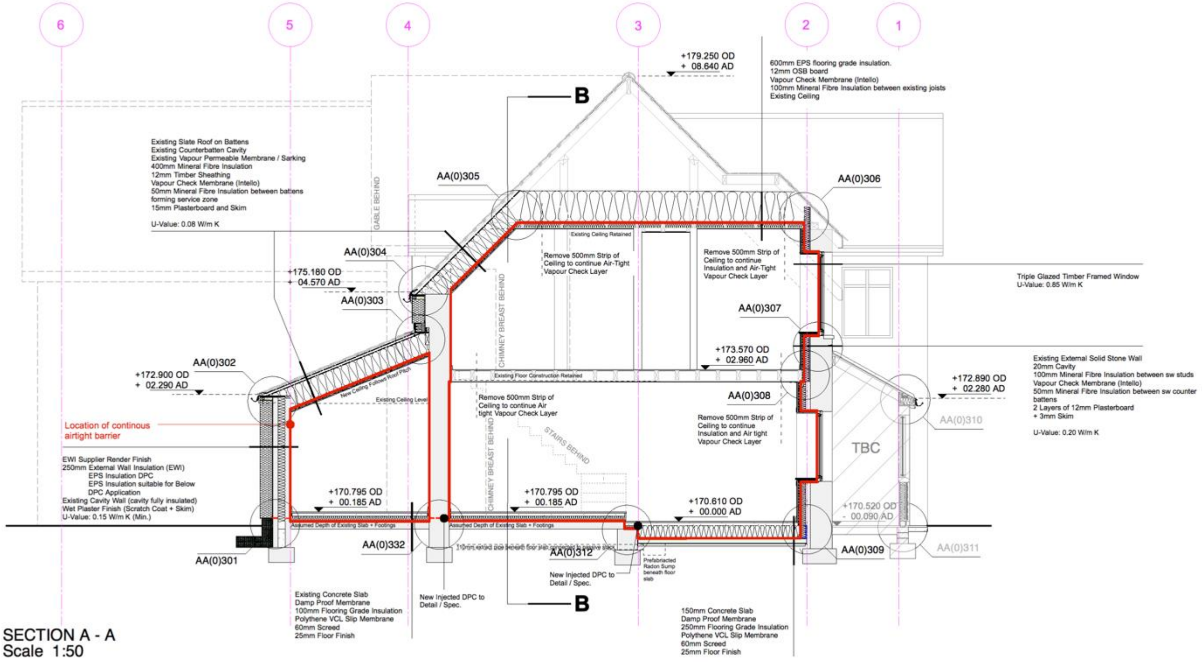
Timber framed, triple glazed windows (not PH certified) were specified for this project with frame u values of 0.93 W/m2K (1.20 W/m2K), warm spacers with 0.032 W/mK. The argon filled, low e coated triple glazing (4/16/4/16/4) achieved a g value of 0.5 and a Ug value of 0.6 W/m2K.

Within areas of internal wall insulation the internal reveals were insulated to improve thermal bridging. Within the external wall insulation the windows were moved into the insulation layer and installed in timber sub frames.

Inward opening triple glazed windows: frames are insulated over on the outside to improve thermal bridging performance.

Windows are installed in subframes and moved into the insulation layer to improve thermal performance

6 Airtightness



Section showing air barrier (red line)

The air barrier within the retrofit part was formed by the following elements:

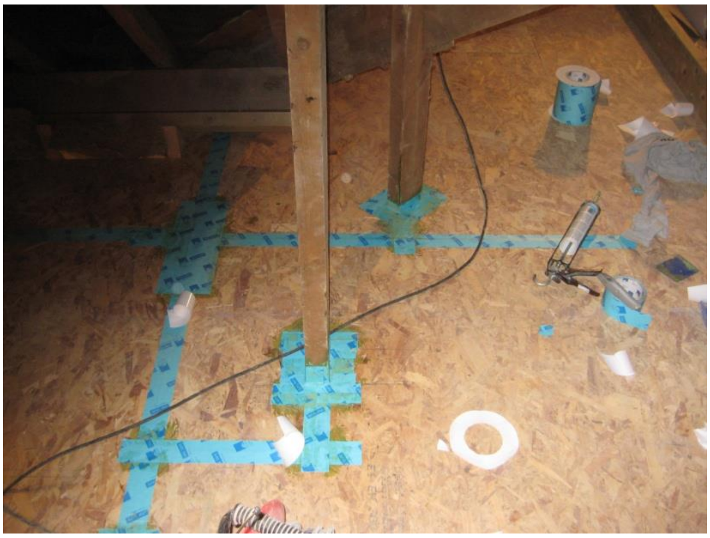
Walls - by the VCL within the internal wall insulation linked to OSB sheathing within roof
Roof – OSB layer laid over existing rafter fully taped at joints and around penetrations.
Floor – gas proof radon barrier linked to DPC and VCL in walls

Within the new extension the air barrier is formed by the following elements:

Walls - by the internal plaster
Roof – OSB board fully taped at joints
Floor – gas proof radon barrier taped and plaster over at ground floor junction

<u>Air tightness detailing</u>

Air barrier to existing walls: existing intermediate floors were cut back to allow for the air barrier to be taped around floor joists



Air barrier to existing roof: OSB boards were laid over existing rafter to acta s air barrier; at the same time the boards formed an ideal working platform to allow air tight joints to be formed with tapes from above

Air barrier to existing: A service void in front of the air barrier minimised service penetrations. To simplify complex geometries like e.g. dormers a combination of OSB boards and VCL membrane details was utilised...

Air barrier to existing: ... still, some complex junction details within the existing structure were unavoidable

Air barrier to new extension: the air barrier in the roof was formed by OSB and linked to the plastered wall with a plaster tape.

Air barrier to new extension: Reinforced plaster tapes were utilised at eave, verge and floor level and around all window openings.

Air barrier to new extension: Sockets were fully bedded into mortar and trunking cut short to allow for continuous plaster layer (air barrier).

6.1 Air tightness test

JSD Air & Acoustic Testing (Buildings) Ltd

Air Permeability Test Report

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5. Test Results

Building Details			**Report Number**	1011/008
Address	Westcott House, Chagford, Newton Abbott			
Post Code	TQ13 8JF	Plot Number(s)	N/A	
Type of Property	5 Bedroom Detached House		Historic Building	No
Date(s) of testing	Tuesday 05 April 2011			

Testing Organisation Details				**UKAS Testing Laboratory No.**	4148
Name	JSD Air & Acoustic Testing (Buildings) Ltd				
Address	Unit 1B Sovereign Way, Trafalgar Industrial Estate, Downham Market, Norfolk PE38 9SW				
Telephone	01366 387354	Fax	01366 387355	E-mail	testing@jsd-aat.co.uk
Name of Test Engineer	Andrew Gromoff				

Client Details					
Name	Mr Neil Tappenden				
Address	Westwinds, Broomhill, Chagford, Newton Abbott TQ13 8DD				
Telephone	07831 340515	Fax	N/A	E-mail	N/A

Statement of results

		Air Permeability (m^3hr/m^2 at 50Pa)		
Test No	Door Used	Value Achieved	Value Standard	Pass/Fail
1	Front Entrance	0.76	1.50	Pass
Test Results =		**Pass**		

Equipment Details

Air Permeability Test Equipment		Serial Number	UKAS Calibration Certificate Number
Fan Blower	Retrotec FN304	097480	UK03939
Micro manometer	Retrotec DM1-001A	097041	UK03940
Wind Speed Meter	Skywatch	JSD 042	U33705-08
Console	Retrotec CU302	95318	UK03939
Transformer	Retrotec FN302A	097255	UK03939

Test Procedures conducted in accordance with Approved Document L, ATTMA Technical Standard 1	Yes
If 'no' describe exceptions and provide reasons	N/A

Test Conditions – Before

Internal Temperature	External Temperature	Average Wind Speed	Barometric Pressure	Average Static Pressure	Average Static Pressure Difference
13.9ºC	11.6ºC	0.6m/s (Max 1.7m/s)	1002.3 hPa	0.69Pa	+/- 0.86Pa

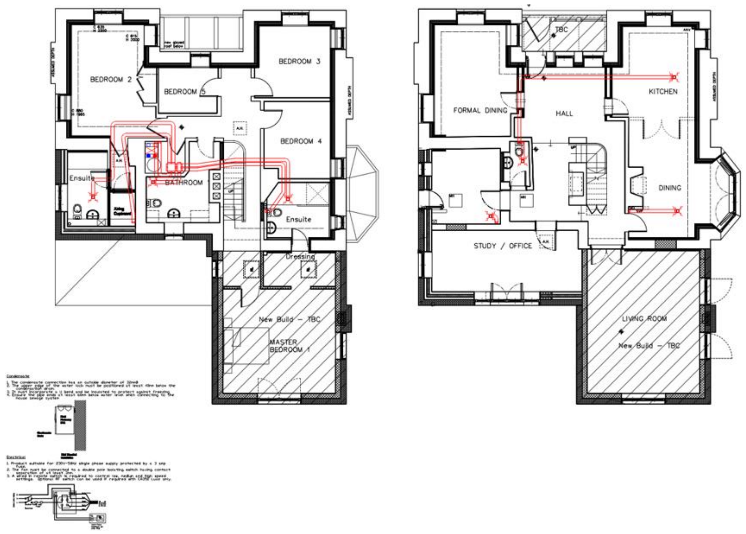
An air permeability test report prepared by JSD Air & Acoustic Testing Ltd.

The completed building achieved the following pressurisation, depressurisation and average air test results:

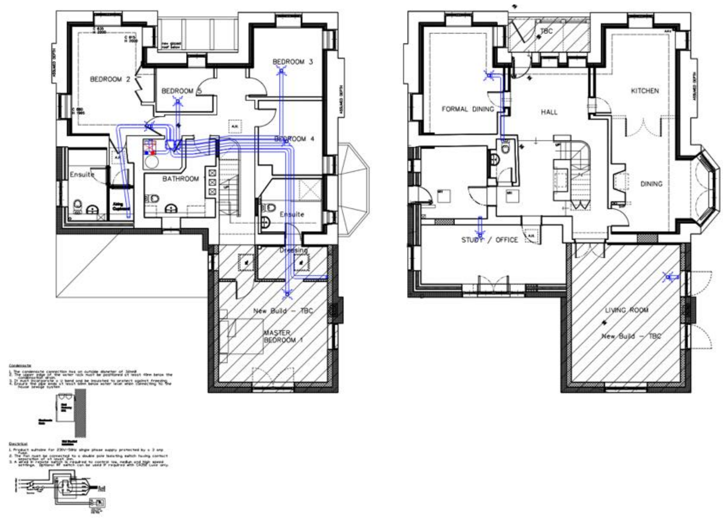
	n 50	**q50**
Pressurisation	0.705	0.72
Depressurisation	0.793	0.81
Average	**0.744**	**0.76**

7 Ventilation design

7.1 Ventilation layout



Suppliers installation drawings of ventilation duct layout – extract ducts



Suppliers installation drawings of ventilation duct layout – supply ducts

The ventilation system is located in a plant room on the first floor to allow for short cold ducts via the roof. Intake and exhaust are behind slate louvres at high level on the gables either side of the North façade. A flexible duct system (Zehnder comfotube) with central manifolds which also acts as cross talk silencers for supply and extract was specified. Air is supplied to bedrooms, formal dining, study and lounge and extracted from the kitchen and WC on ground floor and bathroom and ensuites on first floor. The hall, stairs and corridors are designed as transfer zones with all doors being undercut by 10mm as a minimum. The ground floor is slighty pressurised to assist with radon protection in this high radon location. Cold intake and extract ducts were insulated with 125mm fully vapour sealed insulation..

7.2 Ventilation unit and efficiency

A Passivhaus certified whole house ventilation unit was specified.

Ventilation unit:	Zehnder Comfoair 350
Whole system efficiency (PHPP):	83.1%
Electrical efficiency:	0.31 Wh/m3

Ventilation unit and flexible supply ducts

Supply and extract manifolds

Ventilation control unit located in dining room

MVHR intake and exhaust behind slate louvres on north facing gables

8 Heating and DHW system

Domestic hot water is provided via a thermal store on the first floor connected to solar thermal panels on the south facing roof with electric immersion back up.

Heating is provided via 3 log burners in the hall, the dining room and the lounge. Additional towel radiators within all wetrooms are connected to the thermal store.

Thermal store and air tight range cooker with backboiler option replicating a traditional feature.

Solar thermal panels on south facing roof

9 PHPP verification sheet

EnerPHit verification

ing

Building:	Westcott House
Street:	
Postcode/City:	Chagford
Country:	Devon
Building Type:	Detached Dwelling
Climate:	Plymouth (new)
Home Owner(s) / Client(s):	Sue and Neil Tappenden
Street:	
Postcode/City:	
Architect:	Gale & Snowden Architects
Street:	67 High Street
Postcode/City:	EX43DT Exeter
Mechanical System:	Gale & Snowden Architects
Street:	67 High Street
Postcode/City:	EX43DT Exeter

Year of Construction:	2011	Interior Temperature:	20.0	°C
Number of Dwelling Units:	1	Internal Heat Gains:	2.1	W/m²
Enclosed Volume V_e:	1272.0			
Number of Occupants:	7.1			

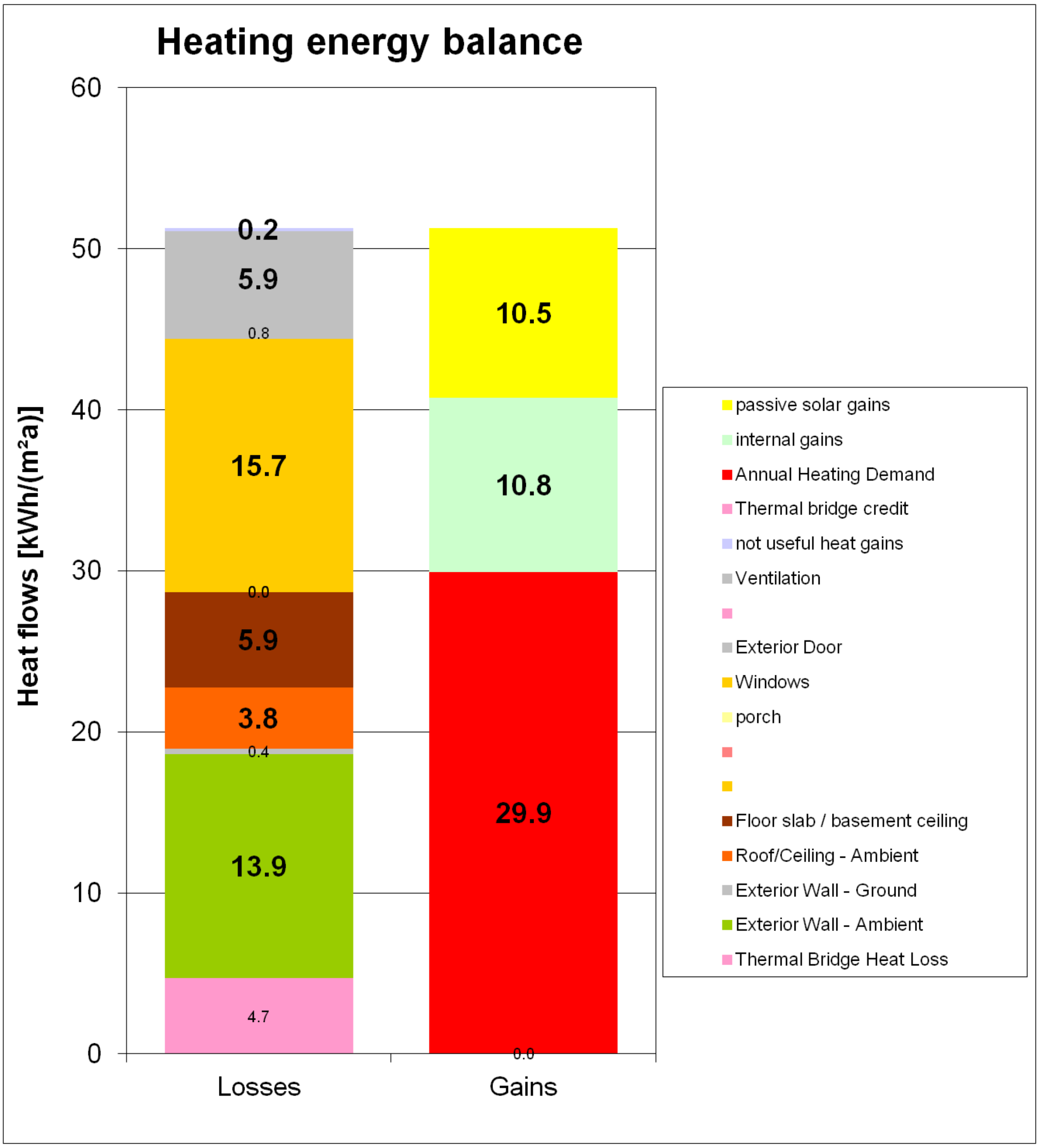
Specific building demands with reference to the treated floor area — use: Monthly method

		Value	Unit	Requirements	Fulfilled?*
	Treated floor area	247.6	m²		
Space heating	Annual heating demand	30	kWh/(m²a)	30 kWh/(m²a)	yes
	Heating load	13	W/m²	-	-
Space cooling	Overall specific space cooling demand		kWh/(m²a)	-	-
	Cooling load		W/m²	-	-
	Frequency of overheating (> 25 °C)	0.0	%	-	-
Primary Energy	Space heating and cooling, dehumidification, DHW, household electricity.	104	kWh/(m²a)	120 kWh/(m²a)	yes
	DHW, space heating and auxiliary electricity	71	kWh/(m²a)	-	-
	Specific primary energy reduction through solar electricity		kWh/(m²a)	-	-
Airtightness	Pressurization test result n_{50}	0.7	1/h	1 1/h	yes

* empty field: data missing; '-': no requirement

EnerPHit building retrofit (acc. to heating demand)? yes

PHPP verification sheet



Heating energy balance calculated using the PHPP; energy losses from windows and external walls proportionally represent the highest losses. Window energy losses also exceed beneficial solar gains and this is mainly due to the orientation of the existing building and planning obligations which didn't allow for any changes to the North elevation. Heat losses from thermal bridging make up about 10% of total energy losses and this is mainly related to foundation details and junction details of the existing solid stonework walls.

10 Construction Costs

The total construction costs for retrofit and extension were approximately €225,000.

11 User experience and actual consumption

House W has been occupied by the same residents since it's completion in 2011. They still enjoy the comfort and air quality of their home. No data on fuel costs or actual consumption was available for this project because the building is predominantly heated with wood from its own garden and surrounding land.

At times, the log burner solution proved challenging for the residents. Especially when returning from winter holidays and when the house had cooled down it took some time to get back to temperature because of the original, high mass, stone walls. For these instances they were considering the addition of an automated solution ie a pellet stove.