Project Documentation

1.0 Abstract

Terrace of five, 3 bed market rent homes at:
84 – 92 (evens) Leah Gardens, Eastleigh, SO50 9QX

Building Data

Year of construction	2018	**Space heating**	**13 Wh/(m^2a)**
U-value external wall	0.187 W/(m^2K)		
U-value ground floor	0.184 W/(m^2K)	**Primary Energy Renewable (PER)**	69 kWh/(m^2a)
U-value roof	0.138 W/(m^2K)	**Generation of renewable energy**	32 kWh/(m^2a)
U-value window	0.84 W/(m^2K)	**Non-renewable Primary Energy (PE)**	165 kWh/(m^2a)
Heat recovery	91 %	Pressure test n_{50}	0.6 h-1
Special features	30 PV panels for electrical generation. ThermalQ Hot Water Cyclinder for Domestic Hot Water Build to Rent scheme for Eastleigh Borough Council		

1.1 Brief Description

Leah Gardens is a development of 94 dwellings for Eastleigh Borough Council. The new estate has been developed as a Build to Rent scheme with 35% of the dwellings being for 'affordable rent' while the remaining 65% are for the private rental market. The whole scheme is therefore part of a new wave of 'council houses' that have been procured in partnership with Vivid, a housing association based in Portsmouth. The Passivhaus dwellings are part of the market rent offer and have been occupied since early 2019.

The Local Authority Planners had allocated the site for the development of housing, and in tandem had produced a Development Brief, which was adopted in April 2009. This set a number of ambitious environmental targets, which included:

- Achieving BREEAM Communities 'Excellent'
- All dwellings to achieve Code for Sustainable Homes Level 4
- 10% of dwellings to achieve Code for Sustainable Homes Level 5 and
- 10% of dwellings to be certified to Passivhaus (however this was later downgraded to 5%)

There was no restriction on which units should be upgraded to Passivhaus, therefore in allocating the provision, a number of key considerations have been taken into account. These included the following:

- Orientation. Dwellings with south facing living spaces were preferred to make the most of solar gains.
- Simple building envelope. The proposed dwellings were generally efficient in their form, however where town houses and flats were proposed, these were not considered appropriate due to complexities in their construction. A 2 storey terrace of 5 houses was therefore preferred where the Passivhaus units are physically seperate from the other, standard dwellings.
- Shading. To make the most of passive solar gains, dwellings which had minimal overshadowing were preferred. This was not possible to achieve completely on this scheme as the dwellings along the Spine Road were all abutted by the dwellings behind, so some of the Passivhaus units were always going to be shaded to a degree.
- Architectural Consistency. Although the general style of the Passivhaus proposals was to be consistent with the rest of the scheme, detailed changes were expected to have an impact on the elevations. Plots were therefore selected where this change would have the minimal overall impact on the composition of the scheme.

Taking these considerations into account, Plots 78-82 were been selected as the Passivhaus units. These plots were all private 3-bedroom, 5 person houses that took the form of a short terrace. This allowed for efficiency in the detailing and construction of the units and avoided any difficult junction details with non-Passivhaus dwellings.

As far as possible, a standard house type was used for the Passivhaus units. There were however a number of physical constraints which have had an impact on the floor plans which has led to the development of a new type, specifically for the Passivhaus units. The key spatial change was the inclusion of a space for the Mechanical Ventilation with Heat Recovery (MVHR) unit. This was accommodated in a cupboard off the first floor landing such that it is central to the plan, minimising duct routes, but also positioning the unit close to the thermal envelope, while making access for maintenance convenient.

The whole scheme was built by the same contractor under a Design and Build procurement route and so there was a desire to standardize as many components as possible. The dwellings were therefore built using an off-site manufactured timber frame with external brickwork cladding to ground floor and blockwork with a cementitious panel to the first floor.

As the plots were terraced, a single PHPP calculation was developed, which gave the scheme advantages in terms of its Form Heat Loss Factor. Where different results were achieved for the airtightness, the worst-case measurement was used in the PHPP.

1.2 Responsible Project Participants

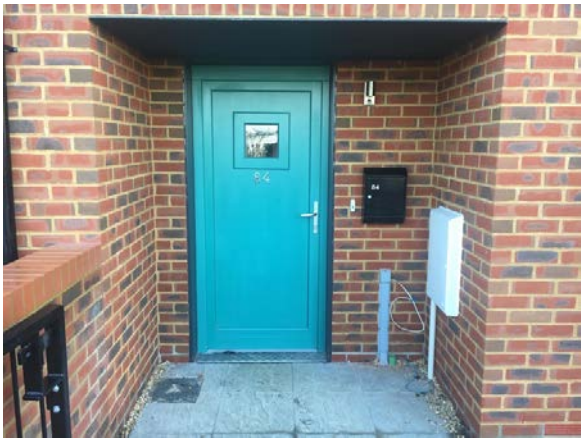
Architect	ArchitecturePLB
Passivhaus Designer	ArchitecturePLB
Client	Vivid & Eastleigh Borough Council
Contractor and Principal Designer	Drew Smith Limited
Employer's Agent	Welling Partnership
Structural Engineer	MJA Consulting
Timber Frame Manufacturer	Roe Timber Frame
MVHR Design and Supply	Green Building Store
Certifier	Warm
Certifying Body	Passivhaus Institut, Darmstadt
Database ID	6136

1.3 Location within Overall Development

1.4 Building Photos

View along north elevation, looking west

View across south facing gardens



Above left: East Elevation
Above: Ground floor window
Left: Front door

View along north elevation, looking west

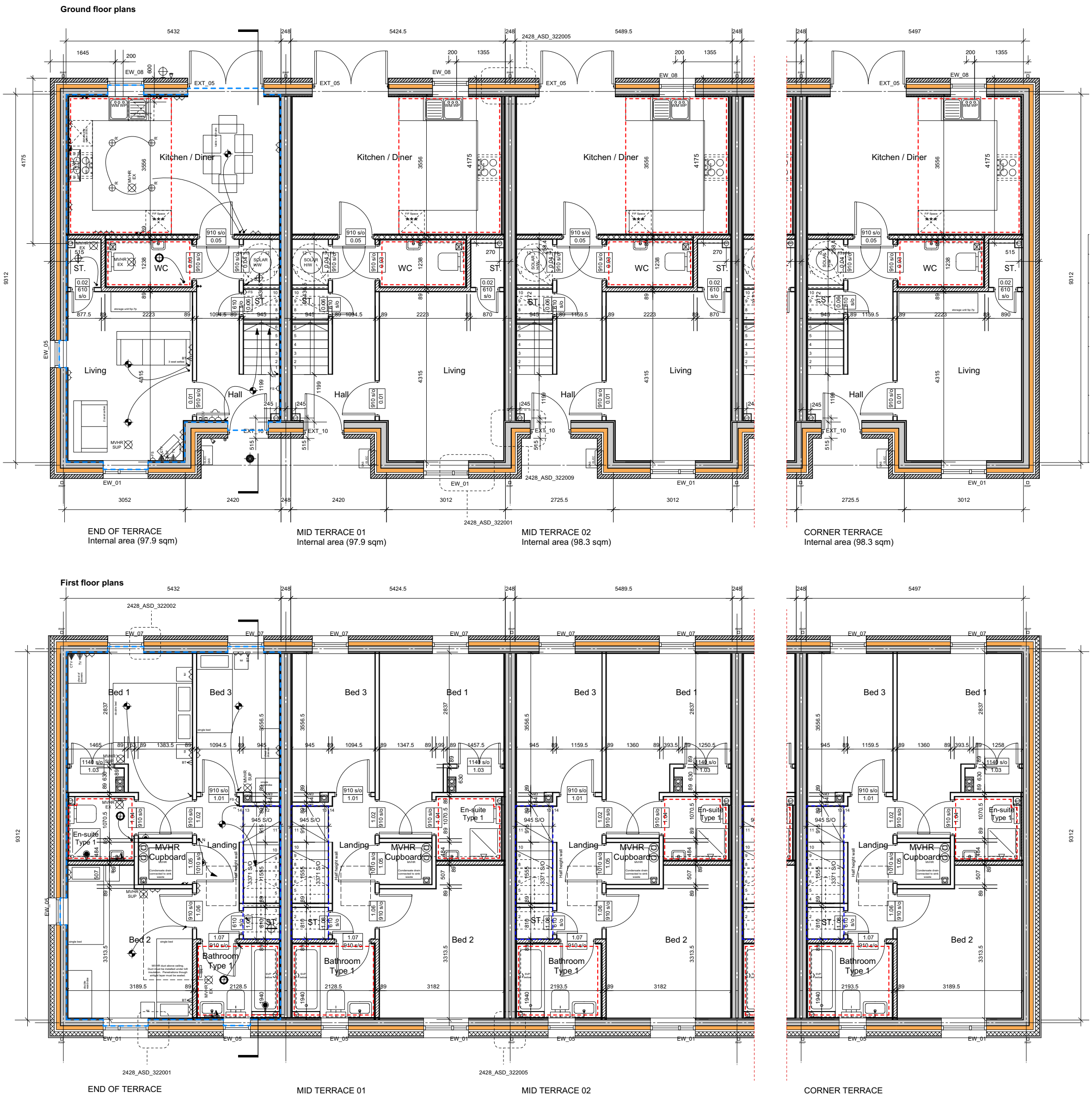
Entrance to Plot 80, with Passivhaus Plaque

Left (photo supplied by Vivid) and below: Typical kitchen, open plan to dining space

Left (photo supplied by Vivid): Patio doors to garden
Below: En-suite shower room

2.0 General Arrangements

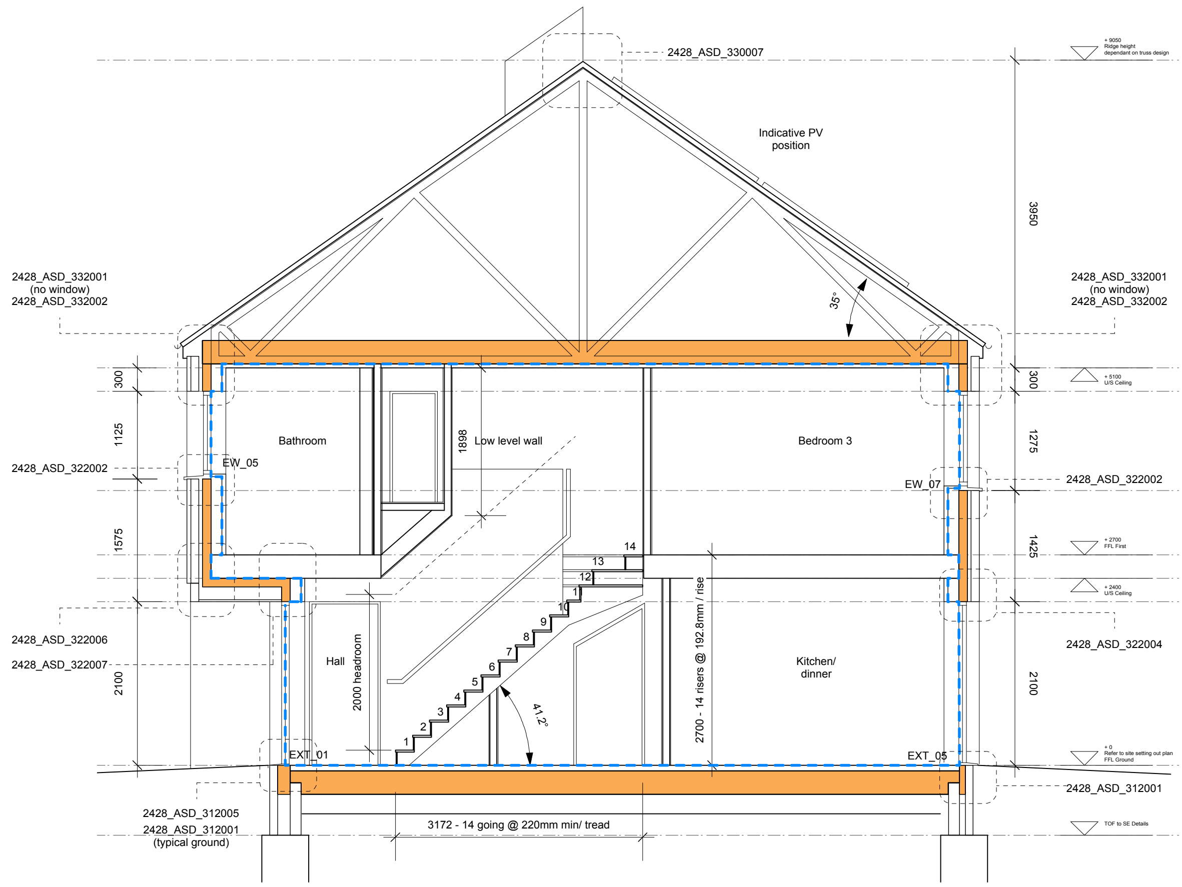
2.1 Floor Plans



The internal layout repeats to each plot, albeit with minor setting out differences which came about due to the constraints of using brick dimensions. Each plot is around 98sqm GIA, with a TFA of 86.5sqm. At the ground floor, the main entrance is recessed to provide shelter, this then provides access to a hall and stair. The living room is located to the front of the house, while an open plan kitchen and dining room runs the full width of the plan to the rear with patio doors to the garden. Between these rooms, is a downstairs WC. The hot water cylinder is located in a cupboard under the stairs.

At first floor, the stairs open to a landing with access to the bedroom, MVHR cupboard, storage and loft access. Bedrooms 1 and 3 are located to the rear of the property, while Bedroom 2 and the family bathroom are located to the front. The MVHR cupboard is therefore central to the plan and also close to the underside of the first-floor ceiling; the thermal envelope.

2.2 Sections



The section through the houses clearly shows the thermal and airtightness lines which are continuous to the external envelope. To enable a consistent foundation design across the wider site, a beam and block construction method was preferred by the contractor. This came with thermal and airtightness risk items, for example where internal load bearing walls pass through the floor, and tolerance concerns regarding installation. To help overcome this, a Tetris floor system was proposed which utilised EPS 'blocks' to bridge between beams, with a second layer of insulation above. Where sleeper walls had to cross the thermal line, a Quinnlite block was used to reduce the impact of the thermal bridge.

The superstructure was also designed to be aligned with the wider scheme and used an off-site manufactured timber frame. A number of options were considered for the external wall insulation. Initially, a mineral wool was preferred to allow it to fit easily between studs, however this would have required additional cavity insulation, which raised concerns over interstitial condensation risk. The resultant proposal used a rigid PIR board in the cavity, which allowed it to completely enclose the superstructure, keeping it all warm.

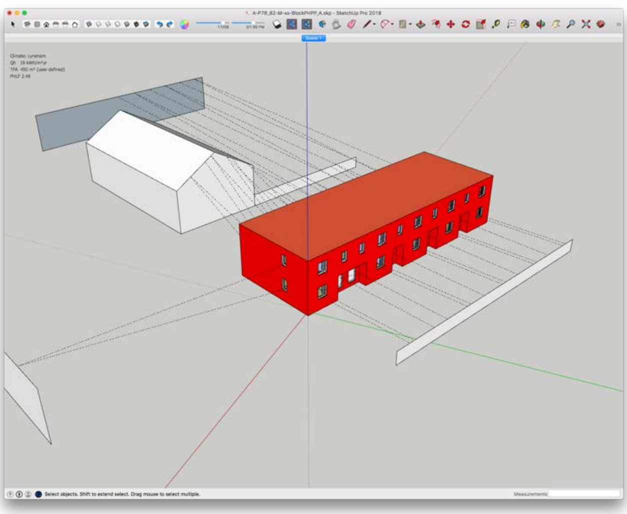
The section also shows the inset front door, designed to create a covered entrance space without the need for a canopy. This presented a further risk area for airtightness and thermal bridging and did require the inclusion of steel beams within the timber frame system. The proposed insulation method reduced the thermal risk as this structure was completely within the thermal envelope.

At roof level, a timber truss was proposed as part of the overall frame system. This was however amended to a 'bob-tail' truss, lifting the pitch above the thermal line and allowing the mineral wool loft insultation to extend to the external wall at a consistent thickness. The roof space is therefore cold and ventilated, remaining outside of the thermal envelope.

2.3 Elevations

The house type elevations show the simple arrangement of windows. These were subtly amended in comparison to the wider scheme and included smaller openings to the north. The south elevation was largely the same as the rest of the scheme.

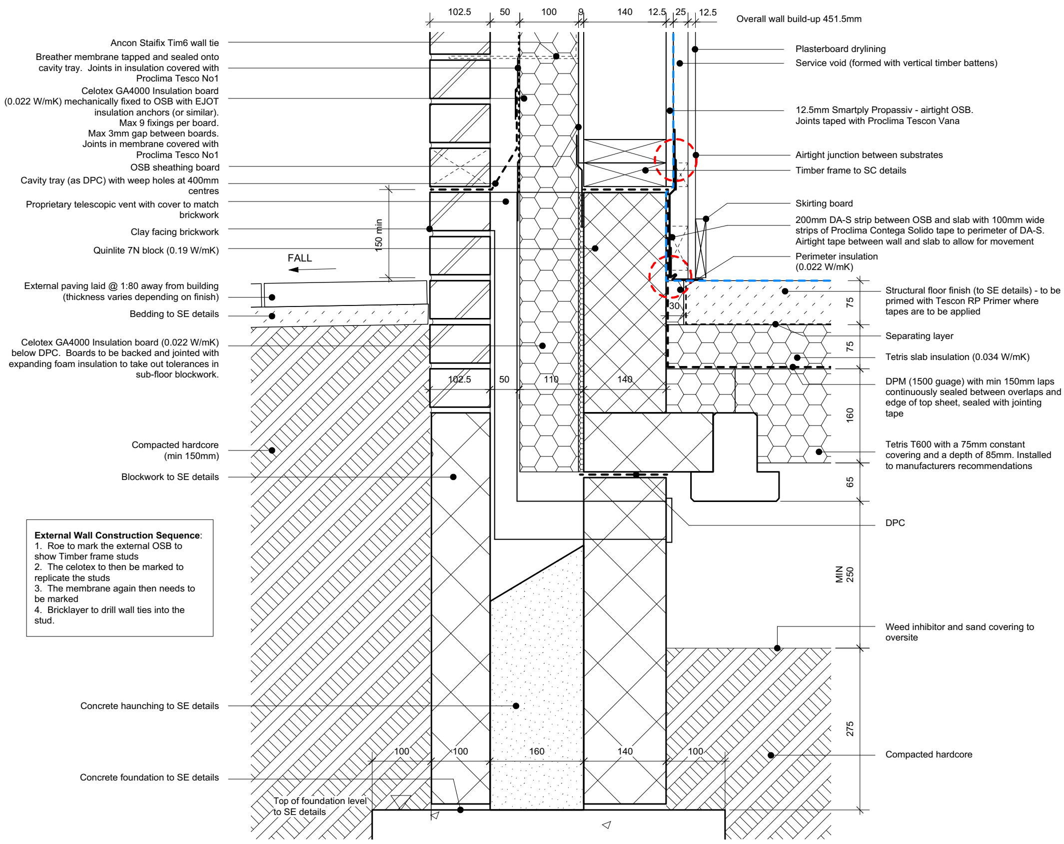
Early design proposals used larger windows to the south to provide additional solar gains, however the good Form Heat Loss Factor (2.48) meant that this was not necessary and actually presented a small overheating risk. The windows were therefore reduced in size, allowing them to be consistent with the wider scheme, albeit to a much higher thermal specification. The alternative would have been to include some shading to these windows, which in this context presented an unwarranted additional cost to the contractor.



Planning stage Design PH sketch up model, used to establish most beneficial window arrangement, which was exported to PHPP.

3.0 Construction Details

3.1 Ground Floor / External Wall Junction



External wall / ground floor junction

This detail shows the junction between the ground floor and the external wall. To ensure consistency of construction across the site, a strip foundation and suspended floor system was preferred by the contractor.

The detail shows the Tetris floor system. This is topped by a concrete structural floor finish, which also acts as the airtightness layer for this element. Flush thresholds were required for accessibility reasons to the front door and rear patio door, therefore the timber frame had to be lifted a minimum of 150mm above the external ground level to comply with NHBC requirements. This therefore required the inclusion of a loadbearing concrete block to the entire perimeter of the building. Although the insulation was taken below ground level to the same depth as the Tetris system, a Quinnlite block was included to reduce the thermal bridge from the sub-floor walls.

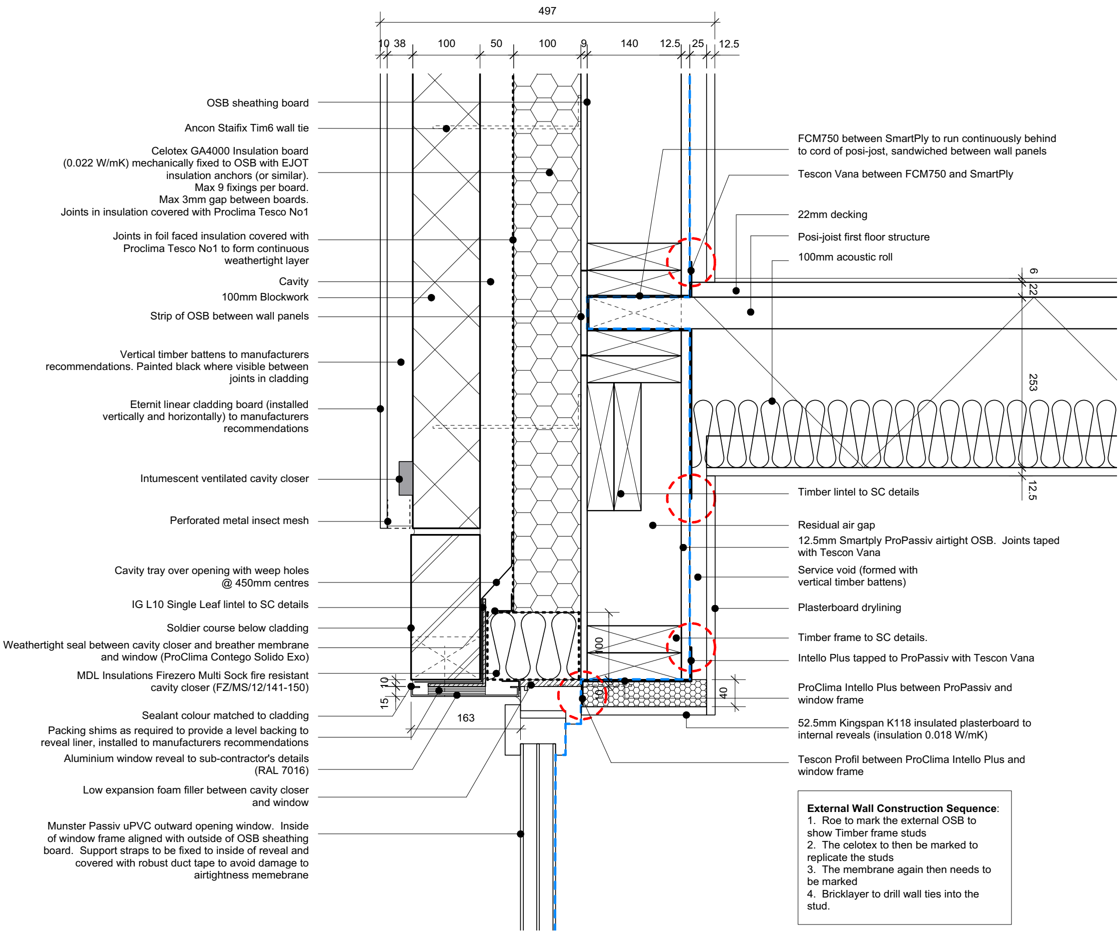
At the door thresholds a Compacfoam structural insulation block was used to avoid a thermal bridge.

Ground floor build-up (from outside)	Concrete oversite with weed inhibitor 250mm underfloor void 150mm pre-cast concrete beams 160mm Tetris Block (85mm between beams / 75mm over beams) DPM 75mm Jabfloor Classic 70 Separating layer 75mm Structural concrete topping	U-value: 0.184 W/m^{2}K

Tetris floor system – photo shows the profile of the insulation block which sits between beams. A second layer of insulation was installed over the top.

Quinnlite blocks, installed to the perimeter of the floor zone.

3.2 External Walls



External wall / first floor junction and window head

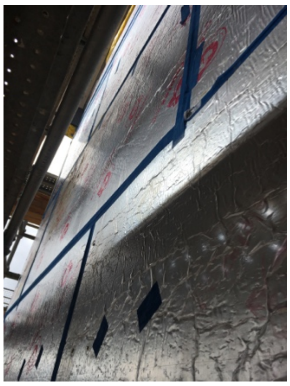
As described above, the contractor's preference for a single construction method for the superstructure led to the use of a 140mm off-site manufactured timber frame, which was wrapped externally in a PIR insulation board, cavity and external masonry. To the ground floor, the buildings are clad in facing brickwork, while above a cementitious cladding panel is fixed to blockwork via timber battens. All of these elements were excluded from the thermal calculations.

The benefit of the external insulation was that it allowed the timber frame to be taken out of consideration when dealing with thermal bridges. As shown in the detail, the frame, including timber lintels over windows could have created awkward spaces to insulate and varied in depth. The proposed strategy allowed the timber frame manufacturer to construct their 'standard product' without impacting on the certification process. Brickwork lintels were specified as single leaf to further separate the thermal layers.

To achieve airtightness, an airtight OSB Smartply board was applied internally. This allowed the contractor to have access to the thermal line up to and past first fix. It did however rely on the use of membranes to bridge the junction between the ground and first floor wall panels. This led to some issues on site as these membranes were not initially installed with sufficient attention to detail, putting the airtightness at risk and so had to be replaced. With more familiarity and confidence, it may be possible to push the airtightness line out to behind the insulation. This would have made navigating these junctions far simpler, but quality control would need to be precise.

External Wall build-up (from outside)	Brickwork / blockwork cladding 50mm cavity 100mm TW55 Cavity Insulation Board OSB structural sheathing board 140mm Timber Frame 12.5mm Airtight sheathing board 25mm service zone 12.5mm plasterboard	U-value: 0.187 W/m^{2}K

Ground floor showing airtight OSB and membrane, lapped around the first floor joists.



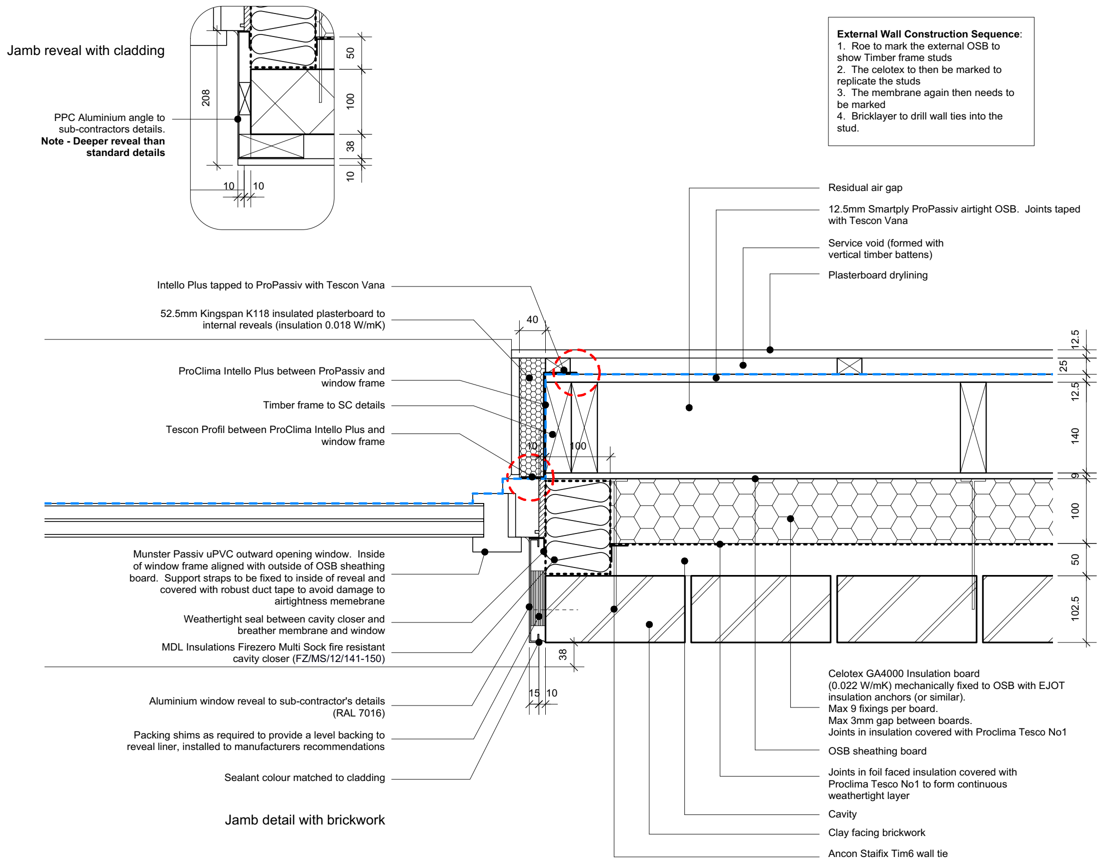
External wall insulation with Weathertightness tape

3.3 Windows

Again, to ensure consistency with the rest of the scheme, a Passivhaus Certified UpVC triple glazed window was supplied by Munster. These were located within the insulation line to ensure continuity of the thermal line. This resulted in the window being set back further into the wall than is conventional with a masonry construction, such that an external reveal liner had to be included in order to cover the cavity closer.

Internally, to help reduce the perimeter thermal bridge, an insulated plasterboard was used which was fixed to the timber frame.

Window Data	Glass – Muster Standard Triple Glazed Unit	U-value: 0.74 W/m^{2}K g-value: 0.55
	Frame – Munster PassiV Future Proof Frame width: 102mm	U-value: 0.77 W/m^{2}K
	Spacer – Swiss Spacer Ultimate	Psi-value: 0.024W/mK

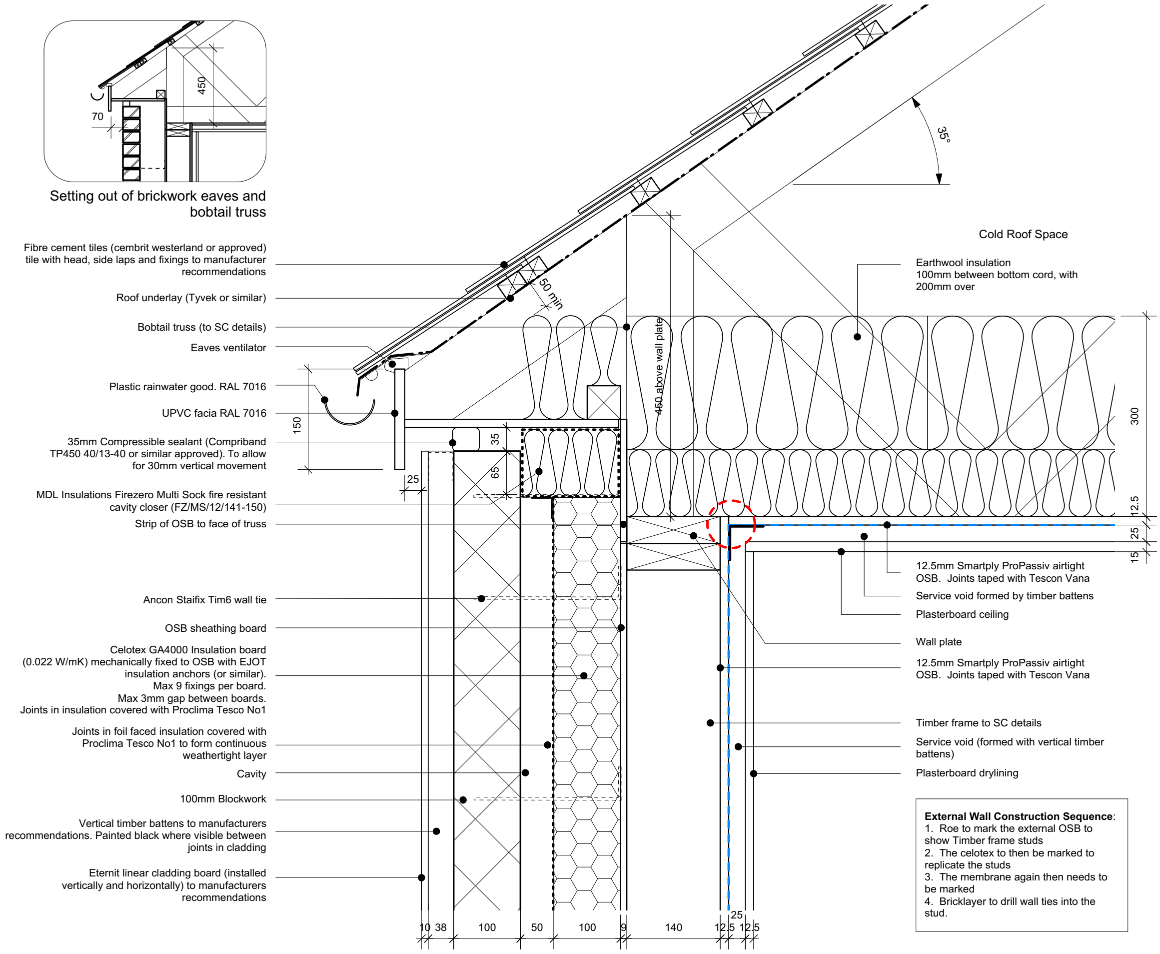


Window jamb detail

3.4 Roof

In order to minimise the FHLF, a cold roof was proposed with 300mm of Earthwool insulation above the ceiling level. As part of the timber frame manufacturers proposals, a trussed roof was used which included trusses at 450mm centres, but with small timber sizes (max 100mm). To allow the loft insulation to extend to the external wall insulation a 'bobtail truss' was proposed which lifted the eaves line up, providing more space for its installation.

One of the challenges in using the Earthwool insulation was that it was easily moved by follow-on trades. Although there should have been no need to access the loft once installed, upon inspection it was found to have been moved in order to establish the location of a hole in the airtightness line. The benefit was however that being very flexible, it could easily be installed between the tightly packed trusses.



External wall / eaves detail

Loft insulation in cold roof space (photo supplied by Drew Smith Ltd)

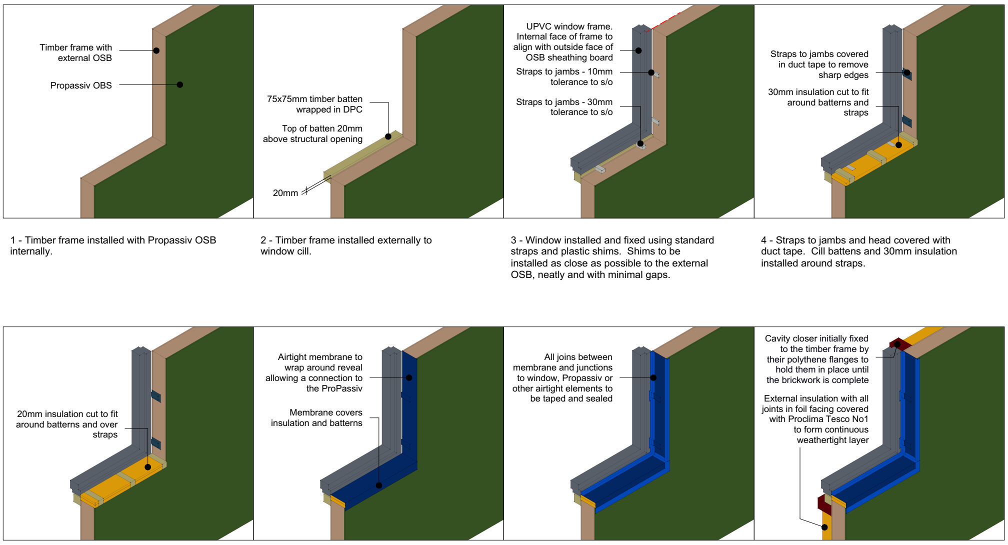
Loft insulation in cold roof space (photo supplied by Drew Smith Ltd)

Roof build-up (from outside)	Fibre cement slate covering 100mm timber truss Cold, ventilated roof void 300mm Earthwool Roll between and over trusses 12.5mm OSB SmartPly 25mm Service Void 15mm Plasterboard finishes	U-value: 0.138 W/m^{2}K

4.0 Airtightness

The airtightness strategy was integral to the detailed design of the external envelope, with aspects being noted in the description of the various elements above. The key element was the SmartyPly ProPassiv airtight OSB board which was proposed instead of a more flexible membrane as it gave a more robust internal finish and backing for the taping of other elements. Proclima products were generally used and the Ecological Building Systems marked-up the construction details to ensure the correct product was specified in each scenario.

The window installation process changed through construction. We had originally proposed brackets fixed to the external sheathing board to keep the fixings outside of the airtightness line. This was however beyond the window installers experience, and so more conventional straps were used. These are often roughly finished and had the potential to puncture the airtight membrane, therefore to ensure that these were accounted for, a window installation sequence drawing was produced as below. This sought to robustly cover the fixings before installing the membrane between the window frame and the ProPassiv board.



1 - Timber frame installed with Propassiv OSB internally.

2 - Timber frame installed externally to window cill.

3 - Window installed and fixed using standard straps and plastic shims. Shims to be installed as close as possible to the external OSB, neatly and with minimal gaps.

4 - Straps to jambs and head covered with duct tape. Cill battens and 30mm insulation installed around straps.

5 - Second, 20mm layer of installation installed between cill board battens.

6 - Proclima Intello Plus membrane installed within internal window reveal

7 - All joints taped and sealed

8 - External cavity closer and insulation able to be installed at any point once window has been fixed.

Note - insulated plasterboard to jambs and head will need to be cut to accommodate the depth of the window straps

Originally, airtightness tests were planned for three stages of the scheme:

1. Completion of envelope when there was a weathertight shell, but the airtightness layer was still exposed,
2. After the 1st fix M&E installation, and
3. Completion of the 2nd Fix and Finishes.

The contractor however struggled to achieve the required airtightness at each stage and so multiple tests were necessary following remedial work. This remedial work was sometimes complex and required the taping of membranes around the loadbearing timber stud partitions, required due to seals being missed early stages of the project. We understand that the contractor has gone on to produce another Passivhau project for a different developer, but put in place much stricter processes for achieving the airtightness target.

Factors that influenced the airtightness results:

- Seals were not put in place under loadbearing partitions.
- Collars were not installed around all SVP penetrations due to them being located too close to walls.
- Loft hatches were initially installed without a second seal.
- Prior to completion a 10mm hole was inexplicably drilled through the airtight OSB into the loft (it is still not known why).

The resultant airtightness levels varied for each plot but are summarised below. The worst-case result was used in the PHPP.

Plot	Pressurisation Result ac/hr @ + 50Pascals	Depressurisation Result ac/hr @ - 50Pascals
No 78	0.58	0.59
No 79	0.51	0.53
No 80	0.55	0.56
No 81	0.63	0.64
No 82	0.59	0.60

ProPassiv OSB

Airtightness test
in progress

Example depressurisation airtightness test report and graph of test readings:

Building Airtightness Test Report

Date of Issue:	23/11/2018	Issued by:	Dave Thompsett
Date of Test:	23/11/2018	Test Engineer:	Dave Thompsett
CPS Scheme:	ATTMA	Registration No.:	1225

Sadler Energy and Environmental Services
2b Poles Copse
Poles Lane
Winchester, Hampshire SO21 2DZ
Phone: 01962 718870
Fax: 01962 718877
Email: enquiries@sadlerenergy.co.uk
Website: www.sadlerenergy.co.uk

Report Number: **DRE116 - Plot 78 Woodside Avenue Eastleigh - Drepre (Stage 3) - kit 1 (Retest)**

Client: **Drew Smith**
Region: **Drew Smith House**
Address: **Mill Court, The Saw Mills, Durley, Southampton, Hampshire, SO32 2EJ**

Plot Number: **Plot 78**
Developers Type:
Development Name: **Woodside Avenue**
Development Address: **Eastleigh, Hampshire, UK, SO50 9ES**

Test Results			
Measured Air Permeability ($m^3.h^{-1}.m^{-2}$)@50Pa	**0.52**	Q_{50}: Airflow ($m^3.h^{-1}$):	**129**
		Design Air Permeability ($m^3.h^{-1}.m^{-2}$)@50Pa	

Test Information			
		Regulation complied with:	
Test Method:	**B**	Test Standard:	**TSL4**
ATTMA TS1 Leakage Area (m^2):	**0.006**	Type of Test:	**Depressurisation**

Building Leakage Curve			
Air Flow Coefficient (C_{env}) ($m^3.h^{-1}.Pa^{-n}$):	**9.0**	Air Leakage Coefficient (C_L) ($m^3.h^{-1}.Pa^{-n}$):	**9.1**
Exponent(n):	**0.677**	Correlation Coefficient (r^2):	**0.9980**

Testing Deviations

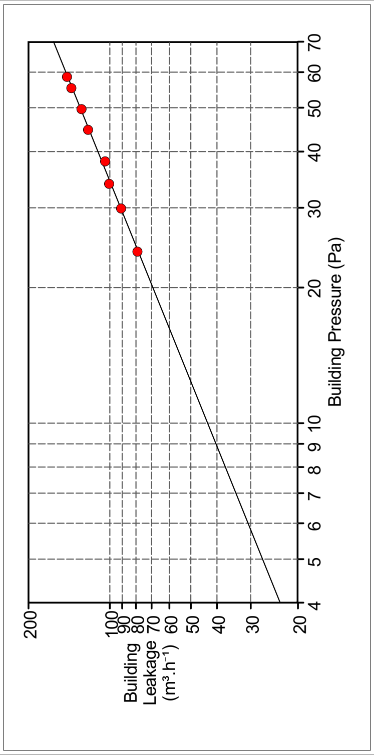
Have any deviations from the 'measurement and equipment' protocol been recorded?	**NO**
Have any deviations from the 'building preparation' protocol been recorded?	**NO**

DEVIATIONS MUST BE CONSIDERED WHEN DETERMINING COMPLIANCE

Page 1 of 4

Building Airtightness Test Report

Air Leakage Graph



Building Information

Building Type	**House - End Terrace**	Building Classification	**Dwelling**
Envelope Area	**248.38**	Primary Construction	**Timber Frame**
Footprint	**49.83**	Primary Heating	**Other**
No. Storeys	**2**	Primary Air Conditioning	**None**
Adjacency to Unheated Space	**None**	Envelope Area Verified	**Yes**
Warm Roof Construction	**No**	Year of Construction	**2018**
No. Significant Penetrations	**8**	Area Under Test	**Whole Building**
Primary Ventilation	**System 4 - Continuous Mechanical Ventilation with Heat Recovery**		
Mastic Sealing Status	**External and Internal Walls (inc. sanitary ware)**		

Building Preparation

Exterior doors and windows closed, internal doors wedged open, traps filled, Ventilation System sealed

Deviation From Standard - Building Preparation

None

Report Number: DRE116 - Plot 78 Woodside Avenue Eastleigh - Drepre (Stage 3) - kit 1 (Retest) Page 2 of 4

Note: values noted in $m^3/m^2/hr$ were recalibrated to ac/h for inclusion in the PHPP (as per table above).

Example pressurisation airtightness test report and graph of test readings:

Building Airtightness Test Report

Date of Issue:	23/11/2018	Issued by:	Dave Thompsett
Date of Test:	23/11/2018	Test Engineer:	Dave Thompsett
CPS Scheme:	ATTMA	Registration No.:	1225

Sadler Energy and Environmental Services
2b Poles Copse
Poles Lane
Winchester, Hampshire SO21 2DZ
Phone: 01962 718870
Fax: 01962 718877
Email: enquiries@sadlerenergy.co.uk
Website: www.sadlerenergy.co.uk

Report Number: **DRE117 - Plot 78 Woodside Avenue Eastleigh - Pressu (Stage 3) - kit 1 (Retest)**

Client:	Drew Smith	Plot Number:	Plot 78
Region:	Drew Smith House	Developers Type:	Woodside Avenue
Address:	Mill Court, The Saw Mills Durley Southampton Hampshire SO32 2EJ	Development Name:	
		Development Address:	Eastleigh Hampshire UK SO50 9ES

Test Results

		Q_{50}: Airflow ($m^3.h^{-1}$):	128
Measured Air Permeability ($m^3.h^{-1}.m^{-2}$)@50Pa	0.51	Design Air Permeability ($m^3.h^{-1}.m^{-2}$)@50Pa	

Test Information

		Regulation complied with:	
Test Method:	B	Test Standard:	TSL4
ATTMA TS1 Leakage Area (m^2):	0.006	Type of Test:	Pressurisation

Building Leakage Curve

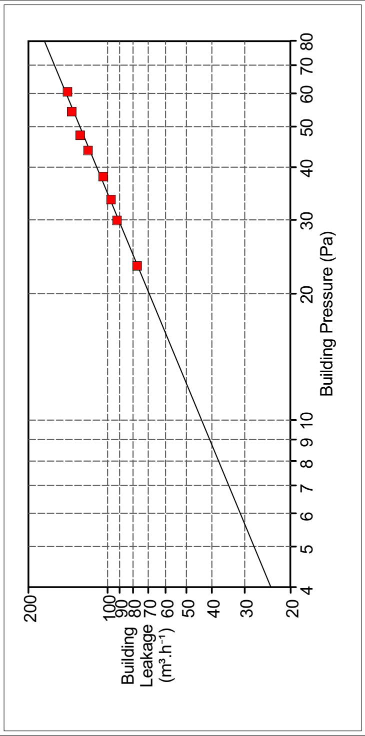
Air Flow Coefficient (C_{env}) ($m^3.h^{-1}.Pa^{-n}$):	9.4	Air Leakage Coefficient (C_L) ($m^3.h^{-1}.Pa^{-n}$):	9.5
Exponent(n):	0.664	Correlation Coefficient (r^2):	0.9964

Testing Deviations

Have any deviations from the 'measurement and equipment' protocol been recorded?	NO
Have any deviations from the 'building preparation' protocol been recorded?	NO

DEVIATIONS MUST BE CONSIDERED WHEN DETERMINING COMPLIANCE

Air Leakage Graph



Building Information

Building Type	House - End Terrace	Building Classification	Dwelling
Envelope Area	248.38	Primary Construction	Timber Frame
Footprint	49.83	Primary Heating	Other
No. Storeys	2	Primary Air Conditioning	None
Adjacency to Unheated Space	None	Envelope Area Verified	Yes
Warm Roof Construction	No	Year of Construction	2018
No. Significant Penetrations	8	Area Under Test	Whole Building
Primary Ventilation	System 4 - Continuous Mechanical Ventilation with Heat Recovery		
Mastic Sealing Status	External and Internal Walls (inc. sanitary ware)		

Building Preparation

Exterior doors and windows closed, internal doors wedged open, traps filled, Ventilation System sealed

Deviation From Standard - Building Preparation

None

Note: values noted in $m^3/m^2/hr$ were recalibrated to ac/h for inclusion in the PHPP (as per table above).

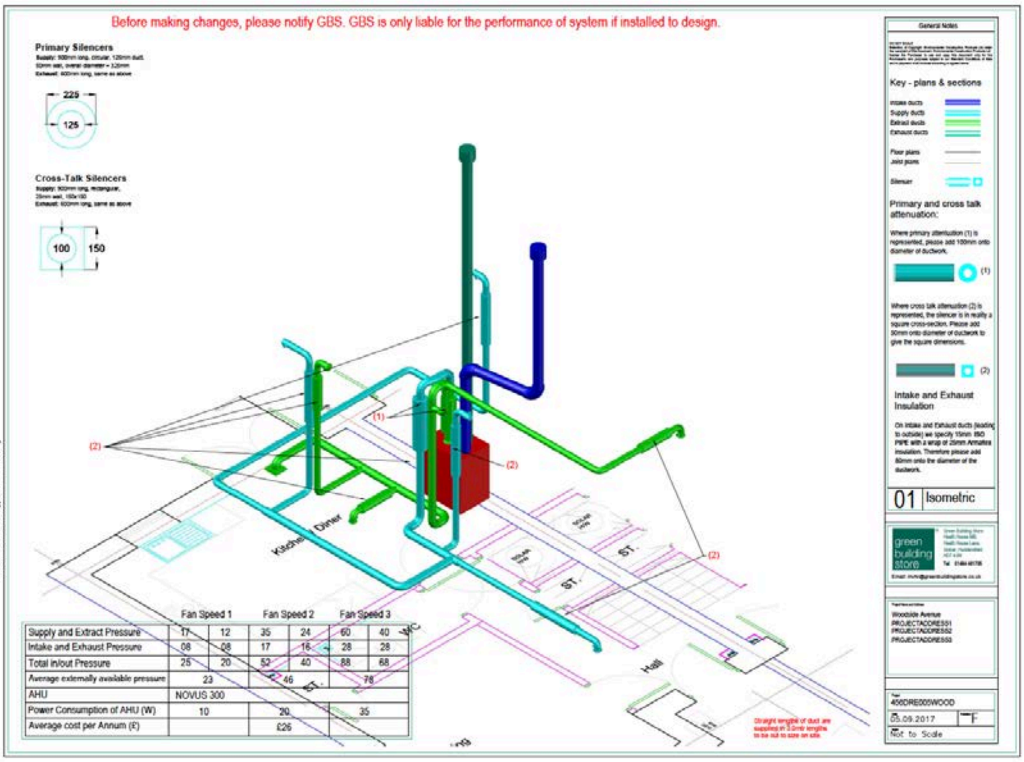
5.0 Mechanical & Electrical Systems

5.1 MVHR

The ventilation system was designed by the Green Building Store using a Paul Novus 300 Unit with rigid circular steel ductwork. This unit has a 93% effective heat recovery efficiency and an electrical efficiency of 0.24Wh/m^3.

The MVHR unit is located in a dedicated cupboard off the first-floor landing. This location allowed the unit to the central to the plan, minimising the ductwork lengths, but also adjacent to the thermal envelope. Intake and extract ducts are therefore within 1m of the loft insulation and while they continue up to roof level once within the roof void they are effectively in a 'cold' area and so further heat loss is not a concern.

Isometric representation produced by the Green Building Store:



Within the building, ducts are generally run through the first floor Posi-Joists (timber joists with a metal web). This includes ducts to first floor rooms as this arrangement was preferred to taking them through the airtightness line. Fresh air was supplied to all habitable rooms (bedroooms and living room) at high level. Undercuts of at least 10mm were provided to all internal doors to allow for an airflow to the bathroom, en-suite and kitchen, where the stale air was extracted. Flow rates, dB(A) noise levels were calculated for each outlet and intake location. The ductwork was installed by the contractor's M&E sub-contractor.

It is worth noting that the Green Building Store design and Roe Timber Frame's engineer worked proactively together to ensure that the timber frame and ducts were well coordinated before the scheme started on site. Due to the length of some of the ducts, these were installed very early in the construction as it would not have been possible to installed them as part of the 1st fix. The design included all component parts, air pressures for commissioning and balancing and door undercut sizes.

Top left and right: Rigid metal ductwork installed within first foor structural zone.
Above left: silencers to the rear to the MVHR unit.
Above: Paul unit in cupboard. Door oversized to allow for removal.
Left: Undercut to door to allow for air flow. (photo supplied by Drew Smith Ltd)

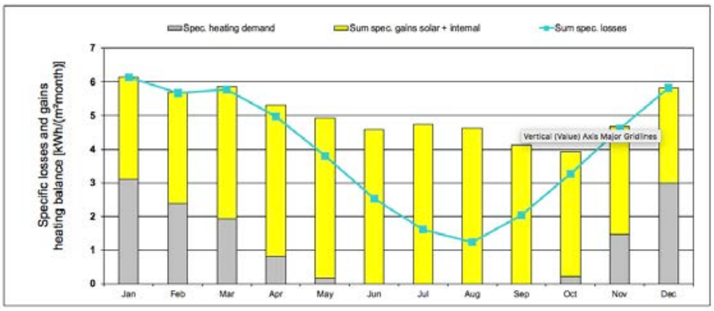
5.2 Heating and Domestic Hot Water

With a heat load of 9W/m^2 it was agreed with the certifier and the developer that a wet heating was not required. In order to provide some top-up heat, an electric towel rail was provided in the bathroom and en-suite shower room. This load was accounted for in the PER worksheet, but was so low that it had minimal impact on the PE Demand.

The developers preference for providing heating and hot water is via a gas boiler system, however with the omission of a wet heating system, the use of a gas boiler for the supply of DHW on its own was questioned and it was ultimately agreed that an all-electric system would be a applied. A ThermaQ Evocyl HE 210L Direct Cylinder with immersion heater has been installed to each house. The tank is insulated with 50mm of PU foam and was designed to be powered in part by Solar PV panels on the roof. The heater is to feed all tapping points, including at the kitchen, bathroom and en-suite.

Each house has 6x 250Wp JA Solar polycrystalline silicon PV panels installed on the south facing pitched roofs. These collectively feed into a Solis Mini 1500 4G Inverter, located in the roof space, adjacent to the loft hatch.

To further help with the certainty of the PE Demand, white good were also identified, including the oven (Indesit IFW 6340 IX UK), ceramic glass hob (Indesit F104275), washing machine (Indesit BWC 61452 S UK – efficiency A++) and the fridge freezer (Indesit F09371).



Immersion heater in the understairs cupboard. Heating Demand monthly graph from PHPP

6.0 PHPP

Verification page from the certified PHPP

Passive House Verification

Building:	84-92 (even)
Street:	Leah Gardens
Postcode/City:	SO509QX Eastleigh
Province/Country:	Hampshire GB-United Kingdom/ Britain
Building type:	Terrace
Climate data set:	GB0004a-Efford
Climate zone:	4: Warm-temperate Altitude of location: 10 m
Home owner / Client:	Drew Smith Limited
Street:	Mill Court, The Sawmills
Postcode/City:	SO32 2EJ Durely
Province/Country:	Hampshire GB-United Kingdom/ Britain

Architecture:	Architecture PLB	Mechanical engineer:	Green Building Store
Street:	St Thomas Street	Street:	Heath House Mill, Heath House Lane
Postcode/City:	SO23 9HD Winchester	Postcode/City:	HD7 4JW Golcar, Huddersfield
Province/Country:	Hampshire GB-United Kingdom/ Britain	Province/Country:	Yorkshire GB-United Kingdom/ Britain
Energy consultancy:	ArchitecturePLB	Certification:	WARM: Low Energy Building Practice
Street:	St Thomas Street	Street:	3 Admirals Hard
Postcode/City:	SO23 9HD Winchester	Postcode/City:	PL1 3RJ Plymouth
Province/Country:	Hampshire GB-United Kingdom/ Britain	Province/Country:	Devon GB-United Kingdom/ Britain

Year of construction:	2018	Interior temperature winter [°C]:	20.0	Interior temp. summer [°C]:	25.0
No. of dwelling units:	5	Internal heat gains (IHG) heating case [W/m²]:	2.7	IHG cooling case [W/m²]:	2.7
No. of occupants:	10.8	Specific capacity [Wh/K per m² TFA]:	60	Mechanical cooling:	

Specific building characteristics with reference to the treated floor area

		Value		Criteria	Alternative criteria	Fullfilled?[2]
	Treated floor area m²	432.3				
Space heating	Heating demand kWh/(m²a)	13	≤	15	-	yes
	Heating load W/m²	9	≤	-	10	
Space cooling	Cooling & dehum. demand kWh/(m²a)	-	≤	-	-	-
	Cooling load W/m²	-	≤	-	-	
	Frequency of overheating (> 25 °C) %	7	≤	10		yes
	Frequency of excessively high humidity (> 12 g/kg) %	2	≤	20		yes
Airtightness	Pressurization test result n_{50} 1/h	0.6	≤	0.6		yes
Non-renewable Primary Energy (PE)	PE demand kWh/(m²a)	165	≤	-		-
Primary Energy Renewable (PER)	PER demand kWh/(m²a)	69	≤	60	69	yes
	Generation of renewable energy (in relation to projected building footprint area) kWh/(m²a)	32	≥	-	14	

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

I 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 verification.

Passive House Classic? yes

Task:	First name:	Surname:	Signature:
2-Certifier	Sally	Godber	
Certificate ID	**Issued on:**	**City:**	
19997-20001_WARM_PH_20190115_PW	Jan-19	Plymouth	

The developer is currently undertaken some light touch POE to ensure that residents are using the homes correctly and are getting the most out of the mechanical systems. They are also monitoring average temperatures and humidity levels.

7.0 Cost

The construction contract covered the entire 94 dwellings, however it has possible to establish a cost for the Passivhaus units, based upon the extra-over costs that were tracked by the contractor. This results in a Project Cost of £811,490 for the Passivhaus units, excluding utilities, fees and preliminaries. Based on the GIA of each dwelling, this equates to £1,656/sqm, or an uplift of 13% over the ‘typical’ dwellings.

Areas where notable ‘extra-over’ costs were required include:

Element	**Description**	**Approximate % of cost uplift**
Groundworks	Use of Tetris flooring over conventional Beam and Block	12%
Timber Frame	Supply and fix of ProPassiv boarding to all external walls, party walls and first floor ceilings	13%
External Walls	Enhanced insulation Inclusion of Quinnlite Blocks (minimal cost)	6% 0.6%
Openings	Inclusion of certified windows and doors	7%
Electrical	Inclusion of heated towel rails Additional PV panels	2.5% 1.3%
Mechanical	Omission of wet heating system Inclusion of MVHR and ductwork	(-10%) 25%
Airtightness	Taping works and materials Testing	12% 1.1%

Other cost increase items were not specifically identified and so have not been included in the list above.