Passive House Project Documentation

A 12 unit affordable housing scheme in Much Wenlock, Herefordshire.

Certified
Passivhaus
Passivhaus Institut
| classic | plus | premium |

1.0 Building Data:

Plots 9 & 10 (added to Passivhaus Database):

Year of Construction:	2017/2018
U Value exterior walls	0.117 W/(m²K)
U Value roof	0.061 W/(m²K)
U Value slab	0.098 W/(m²K)
U Value windows (average)	0.865 W/(m²K)
Heat recovery	87.34%
PHPP Annual:	**15.26 kWh/(m²a) heating demand**
PHPP Primary:	**104.04 kWh(m²a) electric demand**
Pressure test n50:	**0.47h^{-1}**

Overall Scheme Performance Summary:

				U-Values (W/m2K)				
Plot Number	Heating Demand (kWh/m2a)	Heating Load (W/m2)	Heat Recovery	Wall	Roof	Ground Floor	Window	Air-Tightness Result
1-2	15.56	10.36	88.34%	0.117	0.061	0.098	0.860	0.470
3-4	16.47	10.10	87.57%	0.117	0.061	0.098	0.860	0.460
5-6	14.86	9.51	86.48%	0.117	0.061	0.098	0.860	0.420
7-8	14.59	9.85	86.99%	0.117	0.061	0.098	0.860	0.490
9-10	15.26	10.57	87.34%	0.117	0.061	0.098	0.860	0.470
11-12	15.02	10.33	87.34%	0.117	0.061	0.098	0.860	0.390

1.2 Brief Description:

Architype Architects were commissioned by Shropshire Housing Group to design a new 12 unit affordable housing scheme on the site at Callaughton in Much Wenlock. The development consists of 3 No. 3 bedroom (5 person) houses, 7 No. 2 bedroom (4 person) houses and 2 No. 1 bedroom (2 person) houses, all of which are designed to achieve Passivhaus certification.

Special Features: A demanding budget and inexperienced contractor drove a scheme with a very limited energy float, requiring a deeper assessment of thermal bridging.

1.3 Responsible Project Participants:

Architect:	Paul Neep - Architype		
Passivhaus Project Database ID:	5896		
Building systems:	Alan Clarke		
Structural engineering:	Thomas Consulting		
Building physics:	Tom Mason		
Passive House project planning:	Tom Mason		
Contractor:	S J Roberts Construction Ltd		
Certifying body:	WARM		
Certification ID:	19207-19208_WARM_PH_20181031_PW	2 & 4	Callaughtons Ash
	19209-19210_WARM_PH_20181031_PW	6 & 8	Callaughtons Ash
	19211-19212_WARM_PH_20181031_PW	10 & 12	Callaughtons Ash
	19213-19214_WARM_PH_20181031_PW	14 & 16	Callaughtons Ash
	19215-19216_WARM_PH_20181031_PW	7 & 5	Callaughtons Ash
	19217-19218_WARM_PH_20181031_PW	3 & 1	Callaughtons Ash
Author of project documentation:	Tom Mason		
Date, Signature:			

2.0 Views of completed buildings:

3.0 Typical Sectional Drawing:

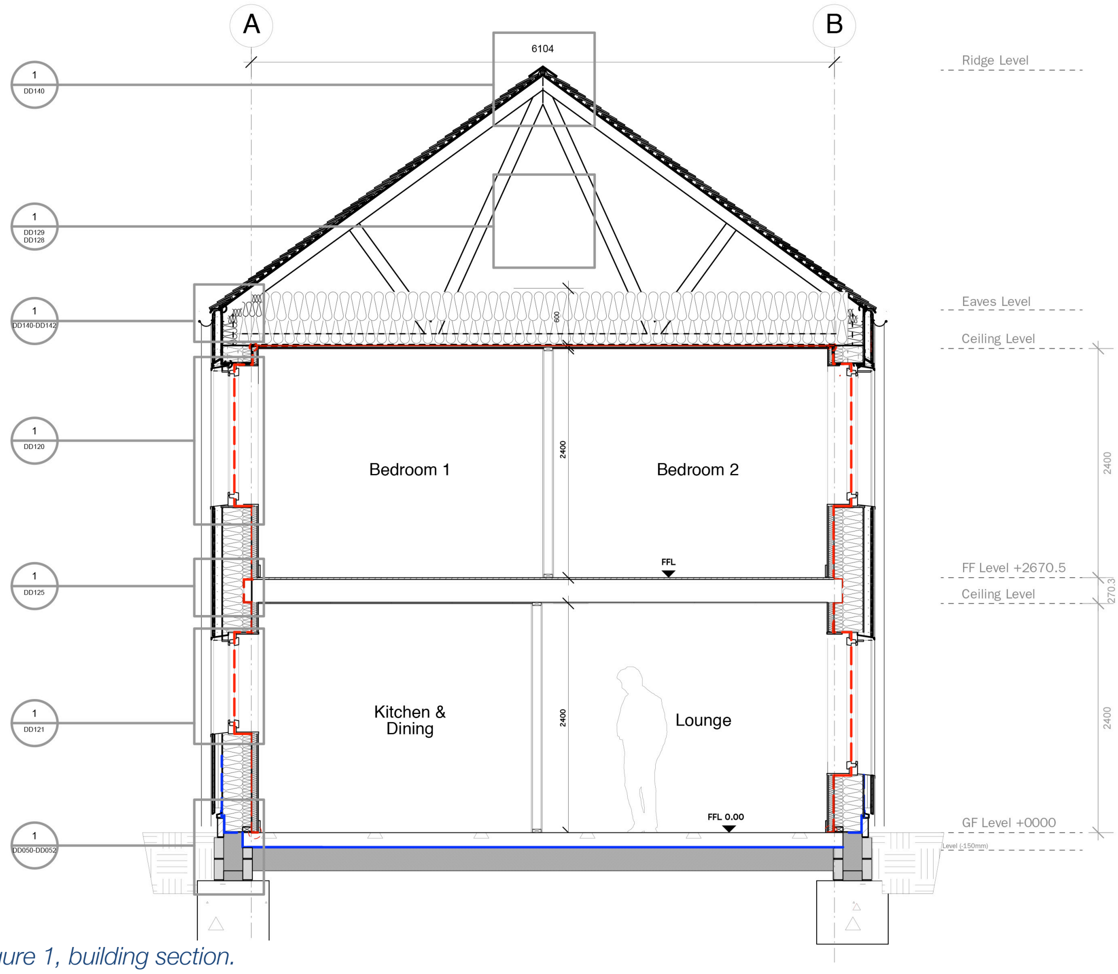


Figure 1, building section.

4.0 Floor Plans:

Site Photo:

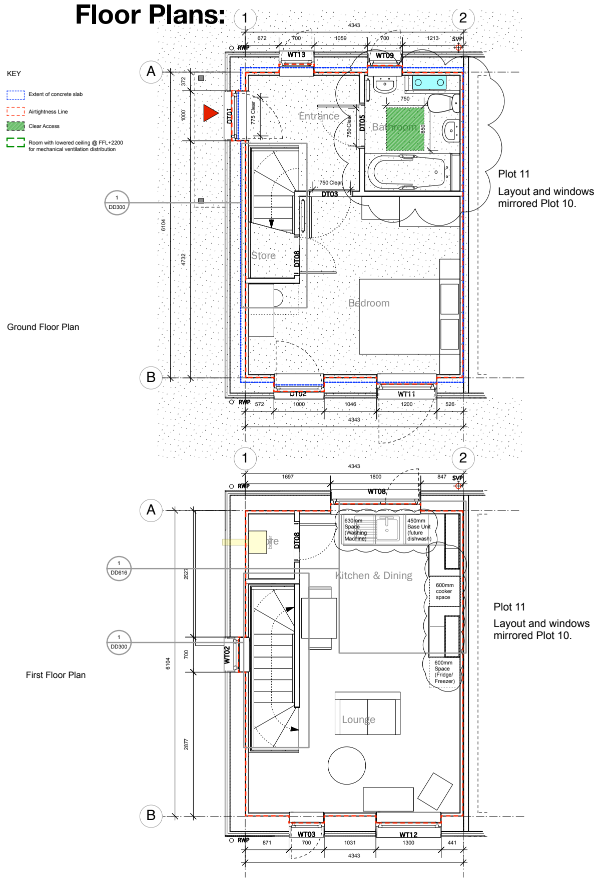
Figure 2, View from site entrance to south, pre-construction.

Site Plan:

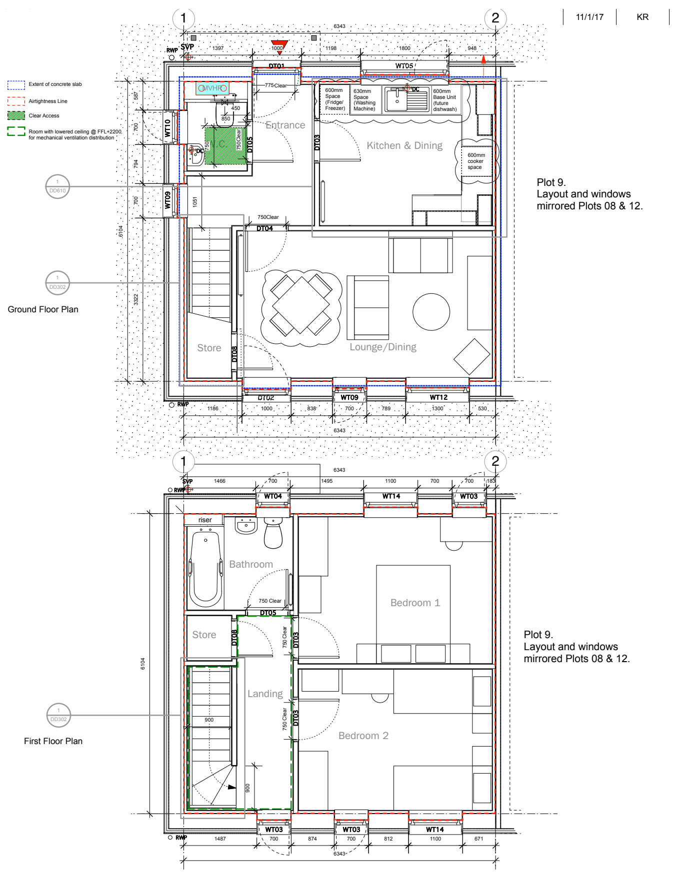
Figure 3, Site plan including plot numbers.

Floor Plans:

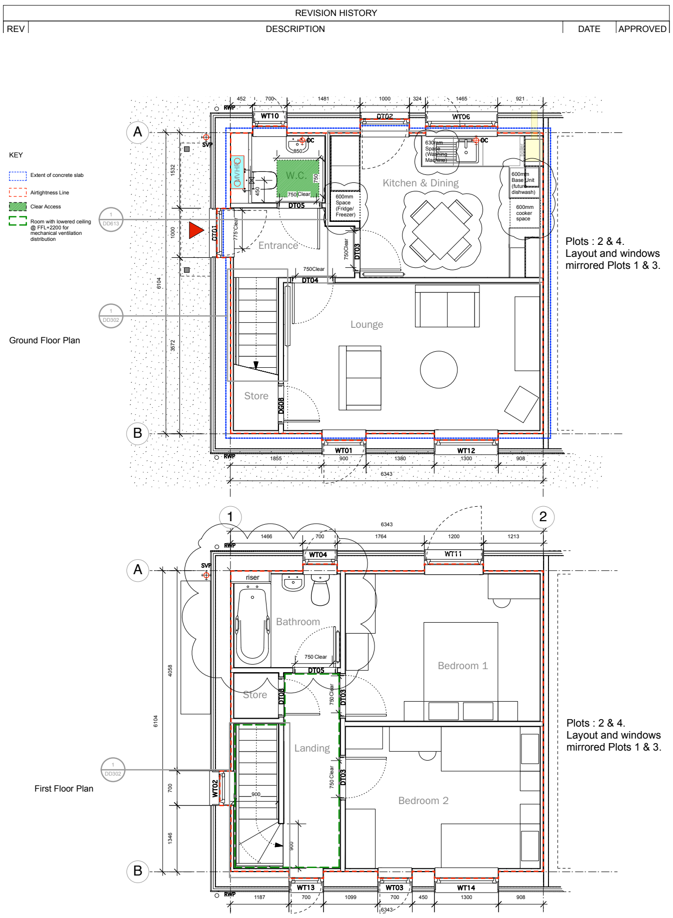
A One Bed, Side Entrance:



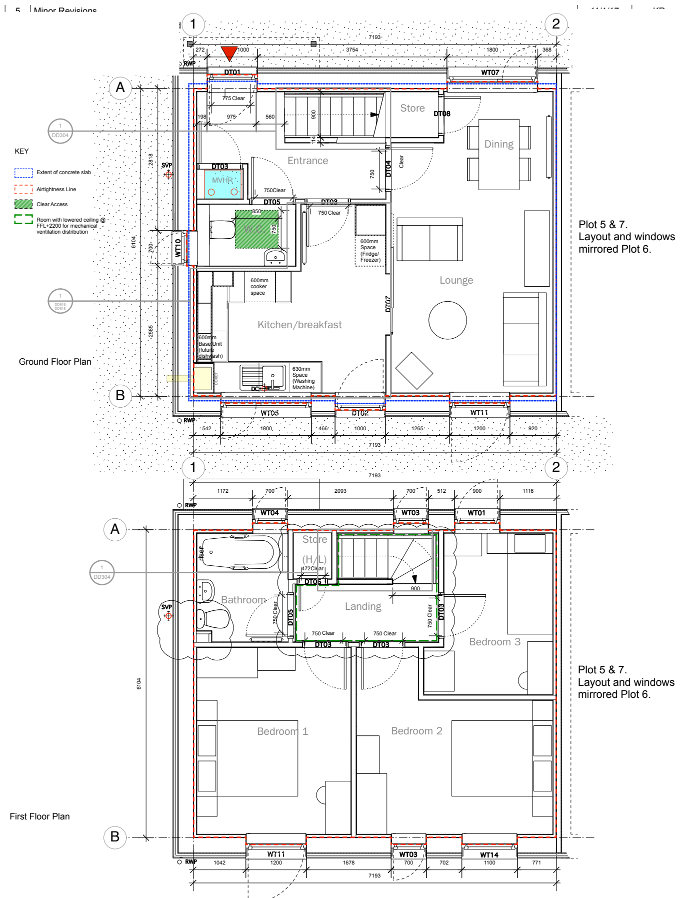
B Two Bed, North Entrance:



C Two Bed, Side Entrance:



D Three Bed, North Entrance:



5.0 Construction Details:

Construction Description:
The proposed construction was a Larson Truss type timber frame fully filled with Cellulose insulation. Lined inside with airtight Smartply ProPassiv board for air-tightness, externally 9mm OSB and Tyvek Firecurb, fire resistant wind-tightness membrane and clad with timber. Due to the sloping nature of the site, the initially proposed slab floating on EPS insulation was hybridised to incorporate a more traditional strip foundation detail. This allowed the foundation to double as retaining walls on key plots.

Construction details:

Cost was a major driving factor in the construction details at Much Wenlock. The walls are designed using a 'larson truss' system which offer significant energy and cost savings over an off the shelf 'I' beam. The roof structure employs a cold roof as in this circumstance the off the shelf product is significantly cheaper and in combination with cellulose insulation is also very cost effective.

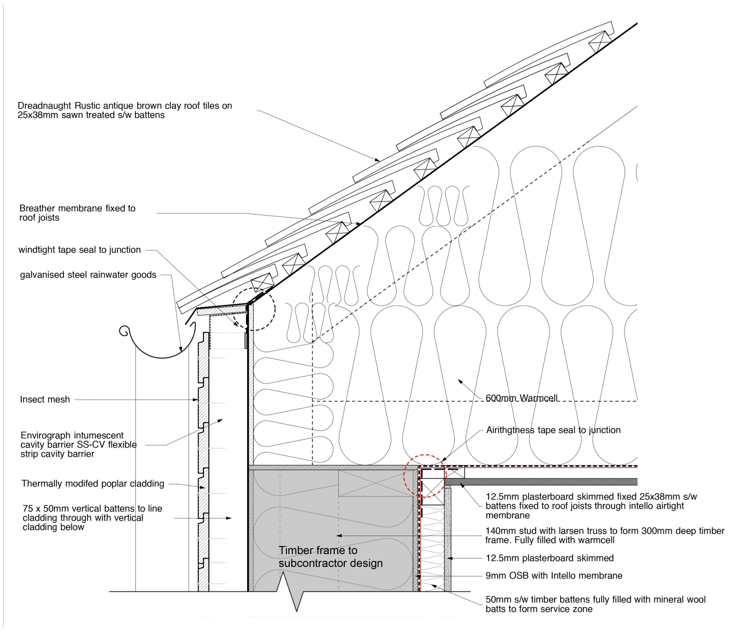


Figure 4, typical roof and wall details.

Window detail:

The installation detail sought to place the window central to the thermal zone. The separated timber (Larson truss) frame created an almost symmetrical structure which was easy to gauge from a psi value perspective. This was also a cost effective solution that was readily adopted by the contractor (who had little experience of Passivhaus projects).

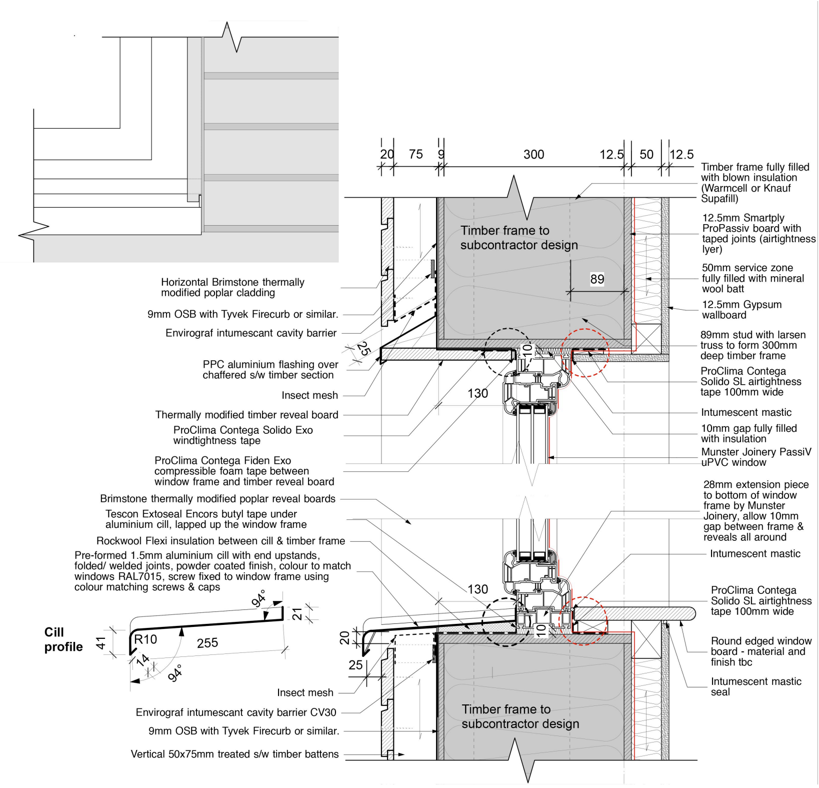


Figure 5, typical head and cill detail.

Plinth detail:

Due to the sloping nature of the site there was a requirement for retaining structures to deal with the disparate levels at different points of the building. This had to be balanced with the need to keep the psi value within acceptable limits. Needless to say, this was one of the key junctions modelled and analysed in PsiTherm.

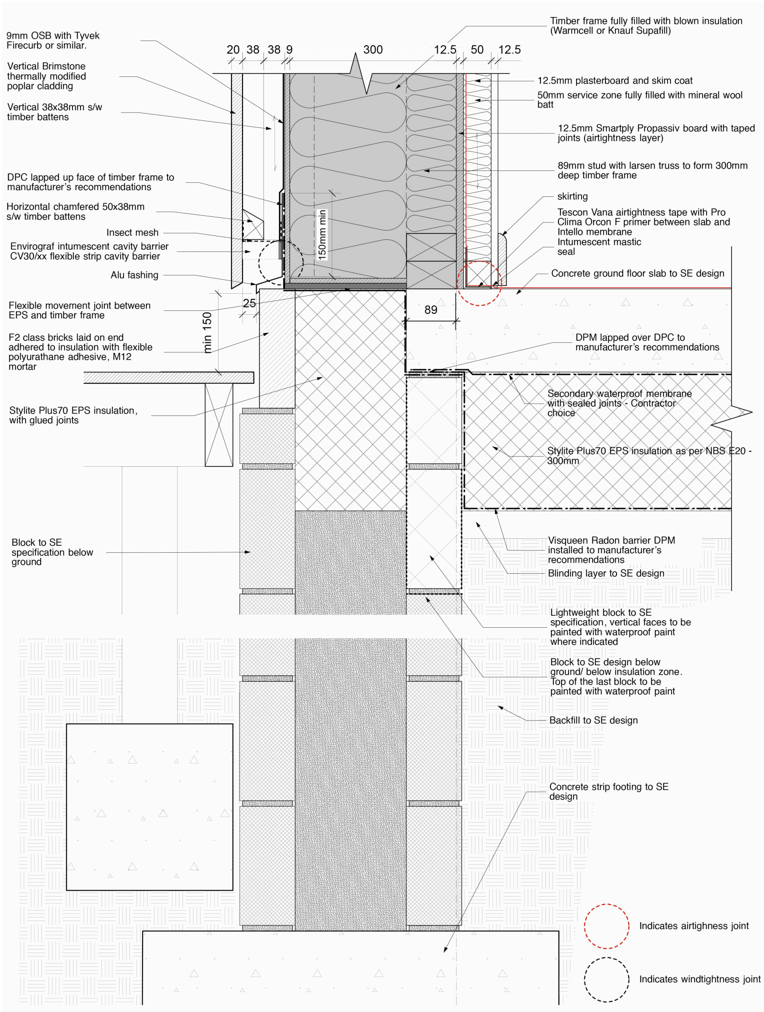


Figure 6, hybrid retaining plinth detail.

Windows:

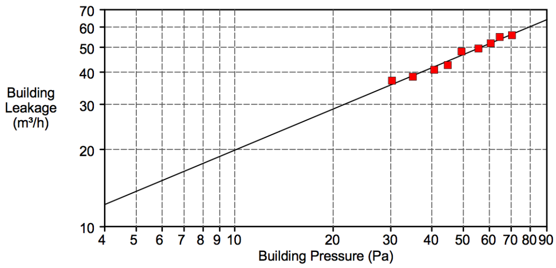
The windows used were triple glazed, uPVC frames from Munster Joinery. uPVC was used due to the tight budgetary constraints. PHPP extracts show different figures for toughened (TUF) and laminate (LAM) glazing varieties as well as opening and fixed lights.

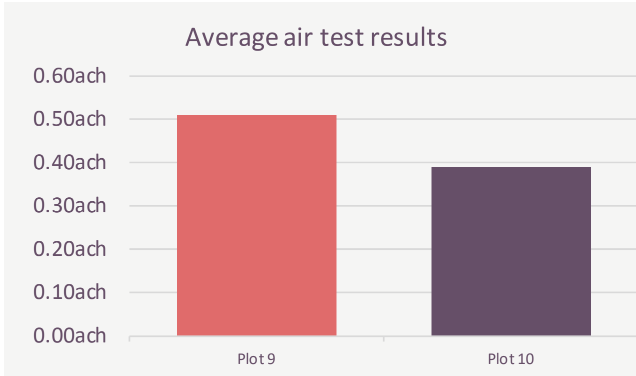
Glazing			Glazing
	Recommended glazing type to start planning: Triple thermally insulated glazing (Please consider the comfort criterion!)		
ID	Description	g-Value	U_g-Value
			W/(m²K)
01ud	4-20-4-20-4	0.63	0.65
02ud	4-20-4-18-6.8/LAM/OBS	0.58	0.57
03ud	4-20-4-18-6.8/LAM	0.58	0.57
04ud	4-20-4-20-4/TUF	0.63	0.65

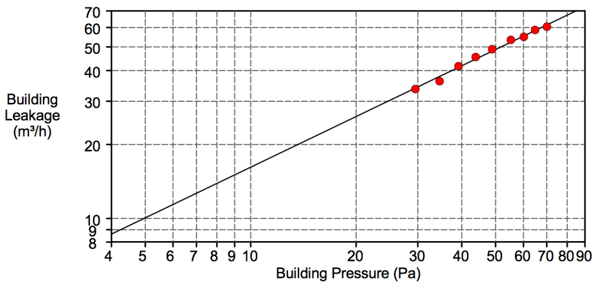
Window frame													
		U_f-Value				Frame width				Glazing edge thermal bridge			
ID	Description	left	right	bottom	above	left	right	bottom	above	$\Psi_{Glazing\ edge}$ left	$\Psi_{Glazing\ edge}$ right	$\Psi_{Glazing\ edge}$ bottom	$\Psi_{Glazing\ edge}$ top
		W/(m²K)	W/(m²K)	W/(m²K)	W/(m²K)	m	m	m	m	W/(mK)	W/(mK)	W/(mK)	W/(mK)
01ud	Munster Joinery - Passiv PVC+ T&T - Super Spacer TriSeal / T-Spacer Premium	0.66	0.66	0.66	0.66	0.125	0.125	0.125	0.125	0.030	0.030	0.030	0.030
02ud	Door kitchen Rehau Geneo	0.90	0.90	1.90	0.90	0.168	0.168	0.143	0.168	0.032	0.032	0.032	0.032
03ud	Door entrance Rehau Geneo	0.90	0.90	1.90	0.90	0.168	0.168	0.143	0.168	0.032	0.032	0.032	0.032
04ud	Rehau - Haustür GENEO PHZ, mit Füllung Rodenberg zweiseitig flügelüberdeckend mit Verglasu	1.12	1.12	1.48	1.12	0.153	0.153	0.111	0.153	0.032	0.032	0.032	0.032
05ud	Munster Joinery - fixed - Passiv PVC+ T&T - Super Spacer TriSeal / T-Spacer Premium	0.67	0.67	0.67	0.67	0.056	0.056	0.084	0.056	0.024	0.024	0.024	0.024

6.0 Description of air-tight envelope:

Due to the pressure on the project to push each area of Passivhaus design it was decided to change the airtightness strategy from 9mm OSB with Intello membrane, hopefully decreasing the final *ach* value. It had been noted that projects with a 9mm OSB and membrane approach had suffered site damage which together with poor workmanship had caused the projects to fail the required 0.6 ach. The airtight envelope was created using a 12.5mm Smartply ProPassiv board which came with very good airtightness characteristics, these would be taped together with Proclima products. The contractor evolved their construction process as they became more familiar with the 'pressures' of airtight construction. The later timber frames were constructed without internal partitions so that the airtightness layer could be examined in full and an initial pressure test completed. The concrete slab formed the air-tightness layer in the ground position.







Plot	initial air test results	Second air test results	Average air test result
Plot 9	0.510ach	0.510ach	0.510ach
Plot 10	0.400ach	0.380ach	0.390ach

Figure 7, Plot 10 pressurisation (top) & depressurisation (bottom) result. Plots 9 & 10 initial and secondary air test results.

Figure 8, showing M&E installation.

Figure 9, showing taped boards and membrane at floor to floor junction.

7.0 Ventilation:

The general strategy for each unit was to supply to the main living spaces, use corridors as transfer rooms and extract from kitchens and bathrooms. In floor plans below blue represents supply and green extract. In an effort to reduce project costs the contractor challenged the original MVHR unit specification. The projects were very close to failing so we carried out an analysis of the impacts of using several different MVHR units. The units were as follows:

1: Zehnder, 90% heat recovery rate, certified PH product, includes frost protection, mid range cost.
2: Dantherm, 93%, heat recovery rate, certified PH product, includes frost protection, mid range cost.
3: Envirovent, 87% heat recovery rate, certified PH product, doesn't include frost protection, low cost.

The Zehnder unit at 90% efficiency and Electric Efficiency of 0.24 Wh/m2 was chosen due to the cost up lift between the Zehnder unit and the appreciably more efficient Dantherm unit.

Ventilation units with heat recovery				
	Recommended specifications to start planning: Frost protection: Yes; Humidity recovery: Yes	75 %		0.45
ID	Description	Effective heat recovery efficiency	Energy recovery value η_{ER}	Electric efficiency
	User defined area	%	%	Wh/m³
01ud	Zehnder Comfoair Q350	90%		0.24

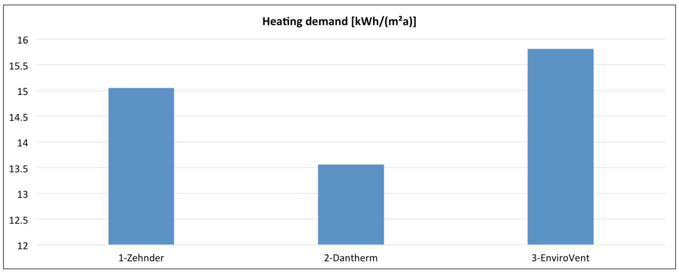
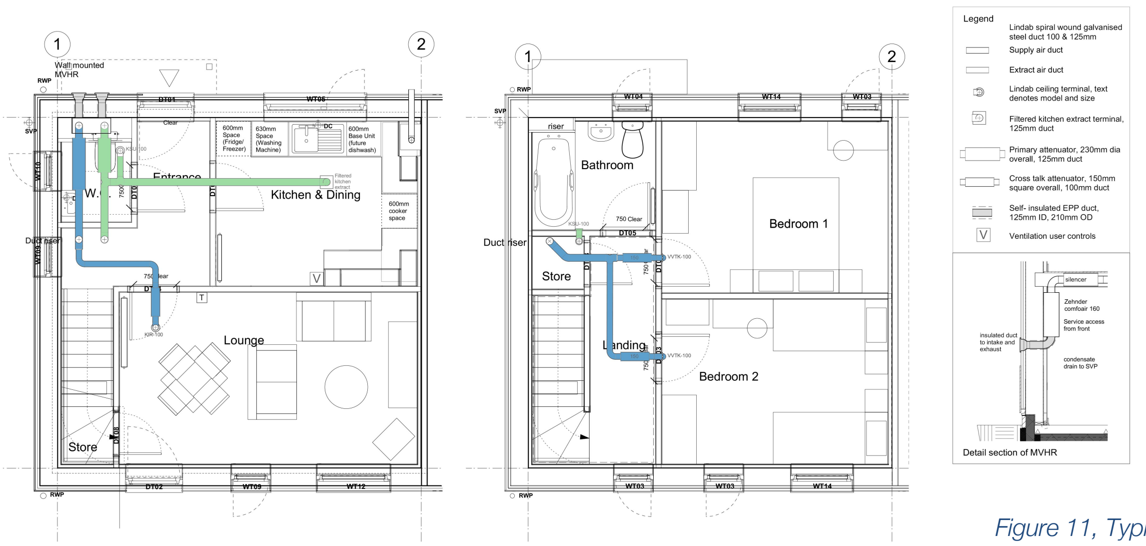


Figure 10, comparative impacts of using different MVHR units and chosen MVHR unit PHPP inputs.



Ground floor plan

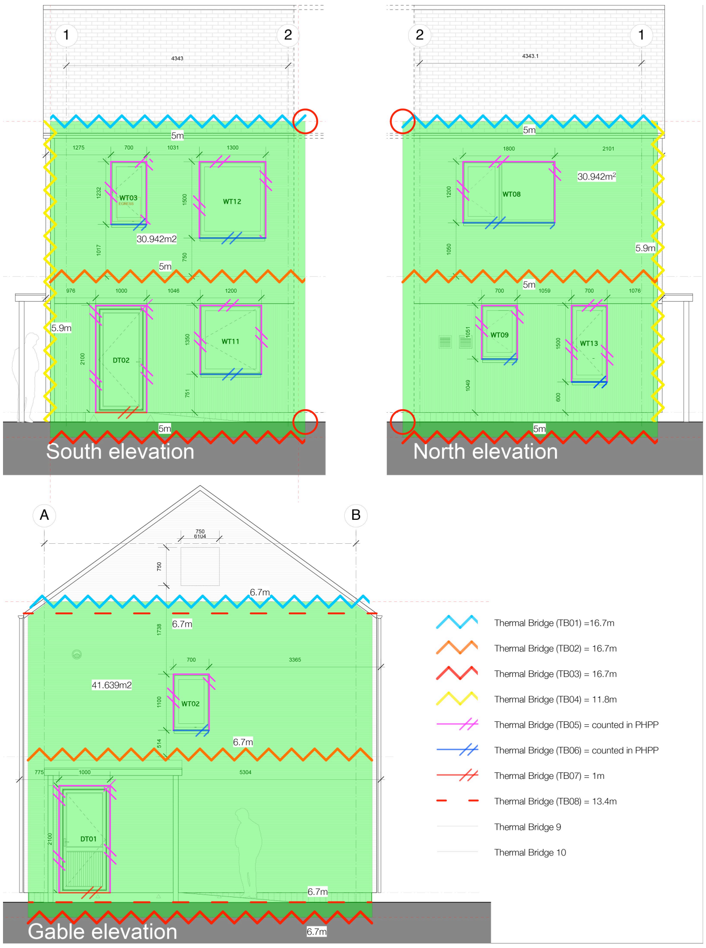
First floor plan

Figure 11, Typical ductwork layout for 2 bed house, north entrance.

Figure 12, before MVHR installation.

Figure 13, detail of MVHR installation.

Structural physics and analysis:
As the plots were semi detached and no pairs were the same, we combined the heat demand and TFA to give us an overall building heat demand. Some of these combined plots were failing and there was pressure from the contractor to retain the same details across the scheme. This caused our results to be sailing very close to the wind. It was deemed necessary to analyse all thermal bridges in PsiTherm. The hope was that due to our robust detailing we could pull back some kWh, especially around the windows and the rather pessimistic assumption of 0.04 installation psi in PHPP. We created a codification of all the thermal bridges (10 no. total) and areas to explain this a little more clearly (see image below).



Nr.	Description	Length	U-value	Correction factor
U1	U1	2.038 m	0.10 W/(m²K)	F_e (1.00)
U2	U2	1.874 m	0.06 W/(m²K)	F_e (1.00)

Thermal bridges calculation
Ψ = -0.055 W/(mK)

Figure 14, drawing identifying all analysed thermal bridges.

Figure 15, typical psi value calculation (TB01) using PsiTherm software.

Unfortunately, this didn't pull the worst-case plots back below the 15kWh/m^{2}a target so we would have to search for further savings. The codified psi values above would be quite difficult to change as they were optimised detail/construction based. The elements that could easily be altered were the internal SVPs, the slab insulation thickness, the wall insulation thickness and the thickness of structural timbers within the walls. We experimented in PHPP with placing the SVP outside the thermal envelope with varying thicknesses of insulation in both slab and wall and with either a 140mm stud or an 89mm structural stud. The most significant effect was removing the SVP from the thermal envelope and after discussing with the certifiers we were happy that we could implement this without further implications.

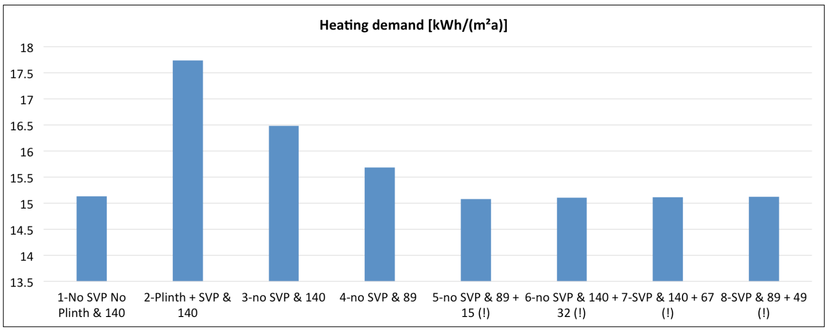


Figure 16, showing different combinations of insulation thickness/stud size and SVP position.

All the analysis and experimentation resulted in the following PHPP results:

Block	# Beds	Plot	annual heating demand (monthly)	TFA	Overheating	Heating Demand
1	2 2	1 2	1986.5 kWh/a	132.0 m²	2.8 %	**15.0 kWh/m²a**
2	2 2	3 4	2021.6 kWh/a	132.0 m²	0.4 %	**15.3 kWh/m²a**
3	3 3	5 6	2227.7 kWh/a	154.3 m²	2.9 %	**14.4 kWh/m²a**
4	3 3	7 8	2215.7 kWh/a	154.3 m²	2.6 %	**14.4 kWh/m²a**
5	2 1	9 10	1681.7 kWh/a	109.2 m²	1.4 %	**15.4 kWh/m²a**
6	1 2	11 12	1657.1 kWh/a	109.2 m²	1.7 %	**15.2 kWh/m²a**

Figure 17, showing the combined heating demand for all 12 plots and associated overheating results.

Success! This had resulted in narrowly passing on the tightest plots (9 & 10). Our evidence was collated and issued to the certifiers.

Certifier feedback:

After compiling our evidence and completing their own PHPP models/ Therm models, the certifiers, WARM, fed back to us their analysis of our calculations.

Hi Tom,

We are happy to accept and incorporate all thermal bridge calculations.

The intermediate floor junction is a slight condensation risk, and we would suggest that in future it would be better to suspend the floor joists off joist hangers that are bolted to the wall, and run the airtight line straight up the inside of the wall. This avoids having an airtight line that goes part-way through the wall structure, as is currently the case.

The certification PHPPs now look like this:

Plots	Heating Load W/m2	PE kWh/m2a
1 - 2	10.07	92.7
3 - 4	10.28	94.1
5 - 6	9.67	82.8
7 - 8	10.02	87.30
9 - 10	10.80	104.7
11 - 12	10.53	100.8

Plots 11 – 12 are passing, to all intents and purposes; it's just plots 9 – 10 that still need a bit of attention.

Some minor comments for later thermal bridge calculations

- The plinth calculation uses an ft of 0.67, but it is not clear how this figure was reached.
- The wall corner calculation includes all services void studs. This isn't necessary. You just need to include any studs that occur within half of the normal repeating distance from the junction.
- There is a problem with the party wall to floor junction, which is clearly around zero. We have therefore not entered this in the certification PHPPs.
- The Passipedia calculation methodology for the party wall to floor is complex, and the final number is a correction for the party wall to floor and the plinth junctions combined. We would recommend carrying out the party wall to floor junction calculation in isolation.

Please find attached the current plots 9 – 10 certification PHPP.

I'm not attaching the evidence register, as there is so little evidence still outstanding, but let me know if you would like a copy. Items outstanding are:

- Close-up photos of threshold(s) showing inclusion of Compacfoam in the detail
- Frame section PDFs for Munster fixed frame windows (Passiv PVC+).

Give me a ring if you would like to talk anything through.

Kind regards,

Liam

8.0 Heat Supply:

The main heating supply was mains gas to a Potteron Promax 28kW combi boiler controlled by a Honeywell wired programmable room thermostat CM701 (24 hour, TPI control) in living room. Radiators were located in kitchen, bathroom, and living room, plus bedroom in 1 bed house. All 600mm high, Types 11,21,22 as indicated below.

Hse type	Plots	Kitchen	Living	Bathroom	Bedroom
1B2P	10,11		22: 1200w 600h	21: 400w 600h	21: 600w 600h
2B4P	1,2,3,8,9,12	21: 800w 600h	21: 1200w 600h	11: 600w 600h	
3B5P	5,6,7	21: 1000w 600h	21: 1200w 600h	11: 600w 600h	

Figure 18, radiator schedule.

Figure 19, Boiler installation.

9.0 PHPP Calculations:

Passive House Verification

Building:	7&5		
Street:	Callaughtons Ash		
Postcode/City:	TF13 6FD	Much Wenlock	
Province/Country:	Shropshire	GB-United Kingdom/ Britain	
Building type:	Semi Detached Dwelling		
Climate data set:	GB0007a-Sutton Bonnington		
Climate zone:	3: Cool-temperate	Altitude of location:	180 m
Home owner / Client:	South Shropshire Housing Association		
Street:	The Gateway, The Auction Yard		
Postcode/City:	SY7 9BW	Craven Arms	
Province/Country:	Shropshire	GB-United Kingdom/ Britain	

Architecture:	Paul Neep, Architype Architects	**Mechanical system:**	Alan Clarke
Street:	Upper Twyford	Street:	The Woodlands, Woodland Close
Postcode/City:	HR2 8AD Hereford	Postcode/City:	GL15 4PL Lydney
Province/Country:	Herefordshire, GB-United Kingdom/ Britain	Province/Country:	Gloucestershire, GB-United Kingdom/ Britain
Energy consultancy:	Tom Mason, Architype Architects	**Certification:**	WARM: Low Energy Building Practice
Street:	Upper Twyford	Street:	3 Admirals Hard
Postcode/City:	HR2 8AD Hereford	Postcode/City:	PL1 3RJ Plymouth
Province/Country:	Herefordshire, 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:	2	Internal heat gains (IHG) heating case [W/m²]:	3.0	IHG cooling case [W/m²]:	3.0
No. of occupants:	3.1	Specific capacity [Wh/K per m² TFA]:	72	Mechanical cooling:	

Specific building characteristics with reference to the treated floor area

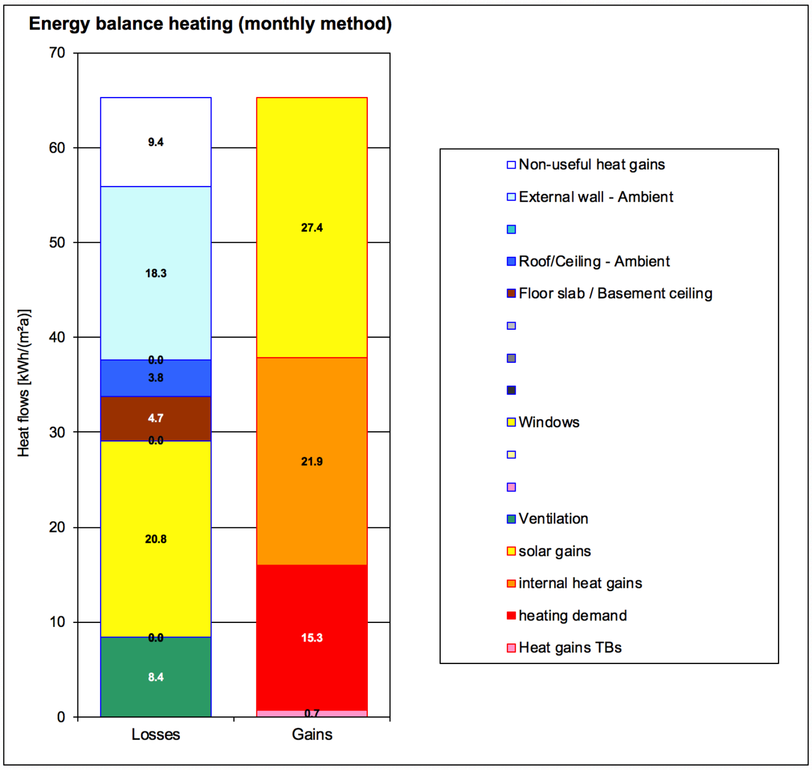
				Criteria	Alternative criteria	Fullfilled?[2]
	Treated floor area m²	109.0				
Space heating	Heating demand kWh/(m²a)	15.26	≤	15	-	yes
	Heating load W/m²	10.57	≤	-	10	
	Frequency of overheating (> 25 °C) %	9	≤	10		yes
Airtightness	Pressurization test result n_{50} 1/h	0.5	≤	0.6		yes
Non-renewable Primary Energy (PE)	PE demand kWh/(m²a)	104.04	≤	120		yes

[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	Peter	Warm	
Certificate ID	**Issued on:**	**City:**	
19215-19216_WARM_PH_20181031_PW	29/10/18	Plymouth	



Figures 20&21, PHPP results from plots 9 & 10.

10.0 Construction cost:

Project costs, including the contractor's assumed (pre contract) £140k uplift over building regulations for Passivhaus construction.

	total cost	(868) per m²	(12) per unit	(48) per bed
Design Fees	£3,000.00	£3.46	£250.00	£62.50
Prelims	£117,000.00	£134.79	£9,750.00	£2,437.50
Siteworks	£9,000.00	£10.37	£750.00	£187.50
Substructure	£143,000.00	£164.75	£11,916.67	£2,979.17
Superstructure	£752,000.00	£866.36	£62,666.67	£15,666.67
External Works	£360,000.00	£414.75	£30,000.00	£7,500.00
Drainage	£85,000.00	£97.93	£7,083.33	£1,770.83
External Services	£66,000.00	£76.04	£5,500.00	£1,375.00
Risk Contingency	£50,000.00	£57.60	£4,166.67	£1,041.67
	£1,585,000.00	£1,826.04	£132,083.33	£33,020.83

abnormals as reported by contractor:	
swales	£32,000.00
retaining walls	£113,000.00
adopted highway	£59,000.00
tree planting	£20,000.00
PH over BRegs	£140,000.00
highway	£40,000.00

Figure 22, Project costs.

Publications and studies:

Passivhaus Trust article:

Passivhaus Trust
The UK Passive House Organisation

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Passivhaus goes Personal

Shropshire homes waiting for Passivhaus certification

This summer residents have been moving in to a their comfortable new homes in Callaughtons Ash. The scheme, designed by PHT Patron member Architype, provides 10 Passivhaus homes for affordable rent and 2 for shared ownership to people with a local connection in Much Wenlock, Shropshire.

The highly sustainable development was built for South Shropshire Housing Association (part of Connexus), and is a model example of a project that unlocks small green land sites and improves the quality of family living in rural areas of the West Midlands. The client's commitment to sustainability, quality and eradicating fuel poverty for housing association residents was the driving force in commissioning this future-proofing Passivhaus scheme.

> *"We have strived to be innovators in the affordable housing sector, whilst taking the concerns of our residents with regards to fuel poverty and other running costs into consideration. We are delighted to welcome our new tenants to their new homes, and hope they will be happy in them for the years to come."*
>
> **Christine Duggan, Director of Housing and Communities for Connexus**

The local community has been closely involved in the project from the very start, with community representatives sitting on a project board from the begining of the design process in 2015 to help decide location, layout and type of construction. With the guidance of SSHA's community-led building consultancy, Marches Community Land Trust Services (CLTS), and adhering to the Much Wenlock Community Plan, representatives learned about construction methods, decided on landscaping and visited the local timber frame manufacturer to see the house frames in construction. Children from Much Wenlock Primary School have also been involved by taking part in a site safety poster competition, making a visit to the site to learn about Passivhaus principles, and helping with the planting of a tree to celebrate the new affordable homes together with local celebrity marathon runner Jimmy Moore.

> *"It has been a great experience working with South Shropshire Housing Association and the local delivery team SJ Roberts on their first Passivhaus project. They truly embraced the standard and have proven that Passivhaus is easily achievable when you collaborate. We are delighted at the reaction of the tenants and look forward to seeing how well the homes are performing through occupation."*
>
> **Paul Neep, Associate and Project Architect, Architype**

Architype have taken a holistic approach to the development. Re-thinking how people use domestic space in modern day families, Architype have reorganised the typical approach to standard home types. Investigating the local vernaculars of Shropshire, the development aims to sit comfortably in its rural surroundings, complimented by a natural palette of UK sourced materials. This includes clay roof tiles that have been quarried and made within 25 miles of the site, lime render provided by local company Lime Green and UK-grown thermally modified hardwood cladding.

Key stats

Homes for affordable rent:	**10**
Homes for shared ownership:	**2**
Average floor area:	**72.5m²**
Construction:	**Timber frame**
Projected value:	**£2 million**
Construction start:	**April 2017**

> *I would like to add that it's been a pleasure to be working alongside the design team headed by Architype in a new form of building. Definitely the way forward in modern day building which sits right in conserving energy in our ever changing world."*
>
> **Mark Philips, Director of SJ Roberts Construction**

Team

Client: South Shropshire Housing Association
Architect: Architype
M&E consultant: Alan Clarke
Contractor: SJ Roberts Construction
Structural Engineer: Thomas Consulting
Certifier: WARM

Further information

Architype

Previous PHT story: Plans for Shropshire Passivhaus homes approved - 9 February 2017

14th August 2018

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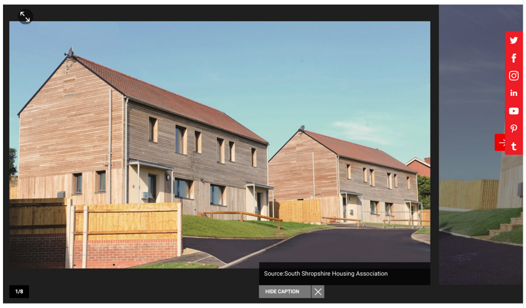
Architects Journal article:

FIRST LOOK

Architype completes Passivhaus affordable housing in rural Shropshire

15 AUGUST, 2018 • BY JON ASTBURY


Source:South Shropshire Housing Association
1/8 HIDE CAPTION

5 COMMENTS

The £2 million scheme – drawing on local vernacular – aims to provide a model for rural developments in the West Midlands

Located on a greenfield site in Callaughtons Ash, Much Wenlock, this £2 million development designed by Architype provides 12 one, two and three-bedroom homes for the South Shropshire Housing Association, of which two are shared ownership and 10 for social rent. With tackling fuel poverty a priority, the housing association decided to follow Passivhaus principles, which can minimise operational costs to around £100 per year for the average house.

Architype, based in neighbouring Herefordshire, has designed the units through 'investigating the local vernacular' of Shropshire, working with what it terms a 'barn aesthetic'. A natural palette of materials sourced locally has been used: clay roof tiles, lime render and hardwood cladding, which has been thermally modified to increase its resistance to decay. Entrances – including entire gables where these contain the main point of access – have been accented with cream-rendered panels.

Architect's view

The site layout and landscape design was particularly challenging as a result of the steeply sloping site, although with the need for brick retaining structures came the opportunity to broaden the palette of landscape materials. The development was ultimately able to reduce water run-off onto the adjoining road through a wider sustainable drainage strategy.

The houses are arranged around a central shared public green space for use by the new community. Through collaboration with local groups, native tree species and wildflower meadows planting form a central part of the development.

Paul Neep, associate and project architect, Architype

SOURCE: ARCHITYPE
Elevations and floor plans (3 bed)

Project data

Start on site date April 2017
Gross internal floor area 3 x 3 bed 84m², 7 x 2 bed 74m², 2 x 1 bed 50m²
Construction cost £2 million
Architect Architype
Client South Shropshire Housing Association
Landscape consultant Node
Structural engineer Thomas Consulting
M&E consultant Alan Clarke
Quantity surveyor WP Housing
Main contractor SJ Roberts Construction
Certifications on target to achieve Passivhaus Certification
Air tightness levels ≤0.6ach @50pascals
Predicted energy demand heating demand 15kWh/m².a, primary energy demand 120kWh/m².a