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:
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.

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.

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.

---

**Table 1:** Recommended glazing type in start planning.

<table>
<thead>
<tr>
<th>Glazing</th>
<th>Description</th>
<th>g-Value</th>
<th>U-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tuf</td>
<td>R-20*+R-6*+LAM</td>
<td>0.65</td>
<td>0.97</td>
</tr>
<tr>
<td>Glu</td>
<td>R-20*+R-6.3*LAM</td>
<td>0.68</td>
<td>0.97</td>
</tr>
<tr>
<td>Glut</td>
<td>R-20*+R-6*LAM</td>
<td>0.69</td>
<td>0.97</td>
</tr>
<tr>
<td>Glut</td>
<td>R-20*+R-6*+TUF</td>
<td>0.65</td>
<td>0.85</td>
</tr>
</tbody>
</table>

---

**Table 2:** Window frame.

<table>
<thead>
<tr>
<th>ID</th>
<th>Description</th>
<th>U-Value</th>
<th>Frame width</th>
<th>Glazing edge thermal bridge</th>
</tr>
</thead>
<tbody>
<tr>
<td>01</td>
<td>Munster Joinery - Pasar PVC+ TST - Super Space Trilateral T-Space Premium</td>
<td>0.58</td>
<td>0.58</td>
<td>0.90</td>
</tr>
<tr>
<td>02</td>
<td>Door vitrificado Rilax-Genes</td>
<td>0.98</td>
<td>0.58</td>
<td>0.90</td>
</tr>
<tr>
<td>03</td>
<td>Door vitrificado Rilax-Genes</td>
<td>0.98</td>
<td>0.58</td>
<td>0.90</td>
</tr>
<tr>
<td>04</td>
<td>Door vitrificado Rilax-Genes</td>
<td>1.12</td>
<td>1.12</td>
<td>1.12</td>
</tr>
<tr>
<td>05</td>
<td>Munster Joinery - Pasar PVC+ TST - Super Space Trilateral T-Space Premium</td>
<td>0.97</td>
<td>0.97</td>
<td>0.97</td>
</tr>
</tbody>
</table>
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 airtightness layer in the ground position.

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

<table>
<thead>
<tr>
<th>Plot</th>
<th>Initial air test results</th>
<th>Second air test results</th>
<th>Average air test result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plot 9</td>
<td>0.510 ach</td>
<td>0.510 ach</td>
<td>0.510 ach</td>
</tr>
<tr>
<td>Plot 10</td>
<td>0.400 ach</td>
<td>0.380 ach</td>
<td>0.390 ach</td>
</tr>
</tbody>
</table>

![Figure 8, showing M&E installation.](image)

![Figure 9, showing taped boards and membrane at floor to floor junction.](image)
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 uplift between the Zehnder unit and the appreciably more efficient Dantherm unit.

![Ground floor plan](image1)
![First floor plan](image2)

![Figure 11](image3)

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

**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).

Unfortunately, this didn’t pull the worst-case plots back below the 15kWh/m²a 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.
All the analysis and experimentation resulted in the following PHPP results:

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

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:

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

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 Compactfoam 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.

<table>
<thead>
<tr>
<th>Hse type</th>
<th>Plots</th>
<th>Kitchen</th>
<th>Living</th>
<th>Bathroom</th>
<th>Bedroom</th>
</tr>
</thead>
<tbody>
<tr>
<td>1B2P</td>
<td>10,11</td>
<td>22: 1200w 600h</td>
<td>21: 400w 600h</td>
<td>21: 600w 600h</td>
<td></td>
</tr>
<tr>
<td>2B4P</td>
<td>1,2,3,8,9,12</td>
<td>21: 800w 600h</td>
<td>21: 1200w 600h</td>
<td>11: 600w 600h</td>
<td></td>
</tr>
<tr>
<td>3B5P</td>
<td>5,6,7</td>
<td>21: 1000w 600h</td>
<td>21: 1200w 600h</td>
<td>11: 600w 600h</td>
<td></td>
</tr>
</tbody>
</table>

Figure 18, radiator schedule.

Figure 19, Boiler installation.
9.0 PHPP Calculations:

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.

<table>
<thead>
<tr>
<th>Item</th>
<th>Total Cost</th>
<th>per m²</th>
<th>per unit</th>
<th>per bed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Design Fees</td>
<td>£3,000.00</td>
<td>£3.46</td>
<td>£250.00</td>
<td>£62.50</td>
</tr>
<tr>
<td>Prelims</td>
<td>£117,000.00</td>
<td>£134.79</td>
<td>£9,750.00</td>
<td>£2,437.50</td>
</tr>
<tr>
<td>Site works</td>
<td>£5,000.00</td>
<td>£53.37</td>
<td>£700.00</td>
<td>£187.50</td>
</tr>
<tr>
<td>Substructure</td>
<td>£143,000.00</td>
<td>£164.75</td>
<td>£11,916.67</td>
<td>£2,979.17</td>
</tr>
<tr>
<td>Superstructure</td>
<td>£752,000.00</td>
<td>£866.36</td>
<td>£62,666.67</td>
<td>£15,666.67</td>
</tr>
<tr>
<td>External Works</td>
<td>£60,000.00</td>
<td>£66.67</td>
<td>£5,000.00</td>
<td>£1,375.00</td>
</tr>
<tr>
<td>Drainage</td>
<td>£85,000.00</td>
<td>£97.93</td>
<td>£7,083.33</td>
<td>£1,770.83</td>
</tr>
<tr>
<td>External Services</td>
<td>£66,000.00</td>
<td>£76.04</td>
<td>£5,500.00</td>
<td>£1,375.00</td>
</tr>
<tr>
<td>Risk Contingency</td>
<td>£50,000.00</td>
<td>£57.60</td>
<td>£4,166.67</td>
<td>£1,041.67</td>
</tr>
</tbody>
</table>

| Total                  | £1,585,000.00| £1,826.04| £132,083.33| £33,020.83|

abnormal as reported by contractor:
- swales
- retaining walls
- adopted highway
- tree planting
- PIH over BRegs
- highway
- other
- £32,000.00
- £113,000.00
- £75,000.00
- £20,000.00
- £30,000.00
- £40,000.00

Figure 22, Project costs.
## Key stats
- Homes for affordable rent: 10
- Homes for shared ownership: 2
- Average floor area: 72.5m²
- Construction: Timber frame
- Project value: £2 million
- Construction start: April 2017

## Further information
Architype

**Architects Journal**
**Architype completes Passivhaus affordable housing in rural Shropshire**

The £2 million scheme – drawing on local vernacular – aims to provide a model for cost developments in the Shropshire area. Located on a greenfield site in Collingham Hall Road, Much Wenlock, the 12 affordable development dignity a holistic approach to energy efficiency and wellbeing. The design, which is based on a local vernacular, incorporates materials and techniques such as recycled timber, lime render, and local clay roof tiles. The project is designed to meet Passivhaus standards and aims to provide energy-efficient, comfortable living spaces for its residents.

**Architype**

**Client:** South Shropshire Housing Association
**Landscape consultant:** Nick Barber
**Structural engineer:** Thomas Consulting
**M&E consultant:** Alan Clarke
**Contractor:** SJ Roberts Construction
**Certifier:** WARM

---

**Team**

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

---

**Publications and studies:**

**Passivhaus Trust**

**Architects Journal**

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**Mark Philips,** Director of SJ Roberts Construction

"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.”

---

**Paul Neep,** Associate and Project Architect, Architype

"Architype have taken a holistic approach to the development. From the design team’s open minds, Passivhaus was the logical extension of this approach. The development is set to include Passivhaus homes for affordable rent and 2 for shared ownership to people in need of a rural connection in South Shropshire, Shropshire.

The highly energy efficient design was set by South Shropshire Housing Association and was to be a holistic approach to modern day building. Architype undertook a holistic approach to modern day building. In doing so, the development has been designed to meet Passivhaus standards and to sit comfortably in its rural surroundings as well as respecting the local vernacular. This includes the use of local materials from the area, the use of local 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.

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.”

---

**Orchid Buggin,** Director of Housing and Communities for Comerz

"We have a hard task on our hands with Passivhaus affordable housing and after having looked into it. We are delighted that it’s been a success and that the homes are performing as we had hoped.”

---

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