Passivhaus project documentation

1 Abstract

Figure 1: Front (north) elevation

1.1 Building data

Year of construction	2015	**Space heating demand**	17 kWh/(m²y)
U-value external wall	0.111 W/(m²K)	**Heat load**	10 W/m²
U-value floor	0.123 W/(m²K)	**Primary Energy**	117 kWh/(m²y)
U-value roof	0.101 W/(m²K)	**Heat recovery**	78%
U-value window	0.84 W/(m²K)	**Pressure test n_{50}**	0.6 h^{-1}

1.2 Brief description of project

The developer, who as a social landlord would retain possession of the houses, had an interest in their energy performance as a means of making them affordable for their tenants. In 2012 they commissioned

Encraft to investigate a variety of options to achieve Code for Sustainable Homes level 4 housing. As a result of our report they choose a fabric first approach, and subsequently settled upon Passivhaus. 19 and 21 Recreation Road are a pair of 3 bedroom semi-detached Passive Houses in a social housing estate of 40 similar houses. The whole estate was built to the same fabric and services specification, with four of them being submitted for and achieving Passivhaus certification. The other two houses, also semi-detached, are located on the opposite side of the road. The blocks, including 19 and 21 Recreation Road, has been treated as a single air tight building with a single PHPP.

The challenge for the design team was to deliver the Passivhaus standard at a budget compatible with the construction of affordable homes. The houses now provide affordable comfortable low energy accommodation for the occupants.

Figure 2: General view of the site

1.3 Project team

Developer	emh homes
Energy consultant	Encraft Ltd
Building design	Halsall Lloyd Partnership Architects
Passivhaus consultants	Encraft Ltd
Contractor	Westleigh Partnerships
Certifying body	Passive House Institute
Certifier	Kym Mead
Certificate-ID	12793_MEAD_PH_20160119_KM
Passive House Database ID	5201
Author	Steven Coulsting

2. Views of 19 and 21 Recreation Road, Sandiacre


Figure 3: Front of 21 Recreation Road


Figure 4: Kitchen prior to occupation


Figure 5: Bathroom internal view


Figure 6: Bathroom internal view

3. Sectional drawing

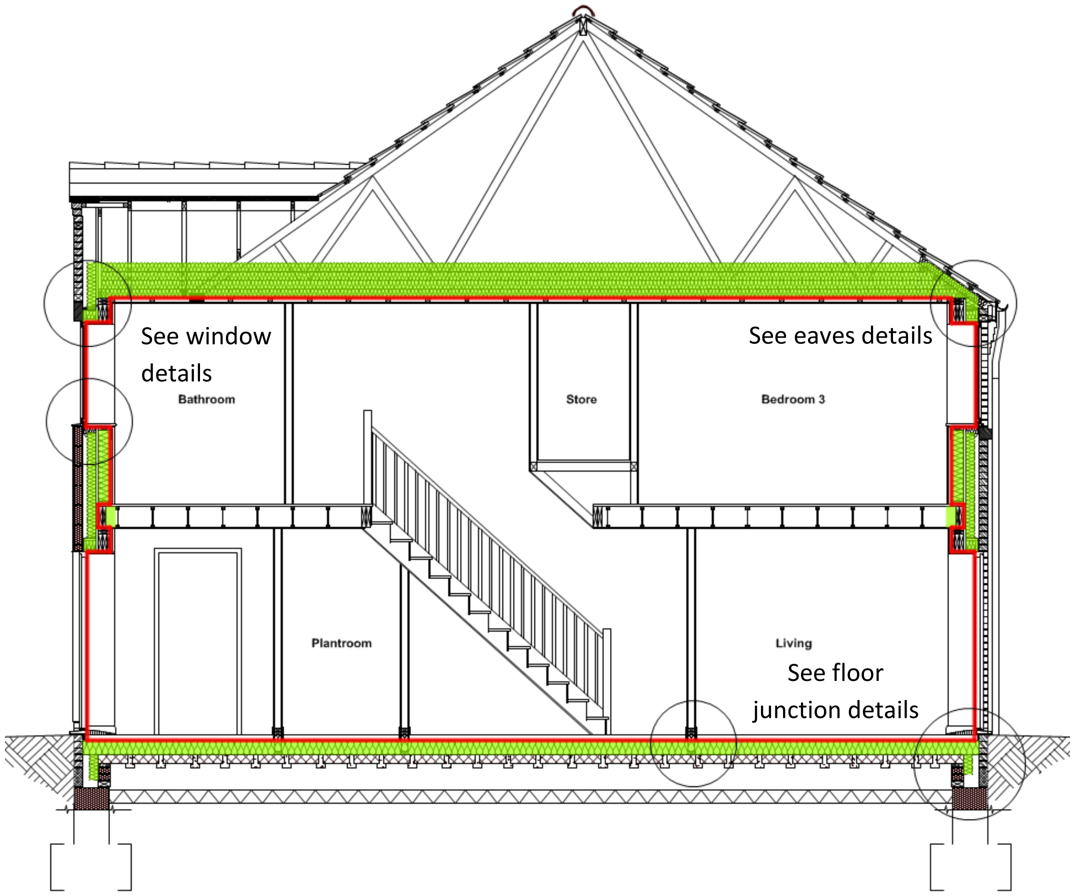


Figure 7: Section through 19 Recreation Road

Insulation is shaded light green. The air barrier is indicated by a continuous red line.

4. Floor plans

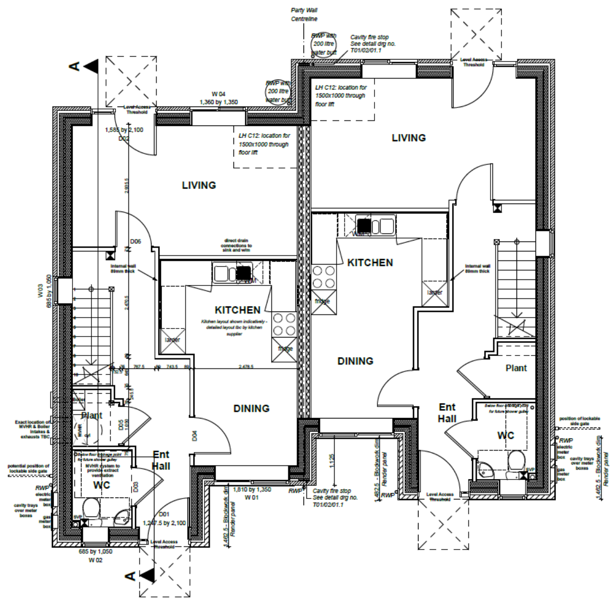


Figure 8: Ground floor plan

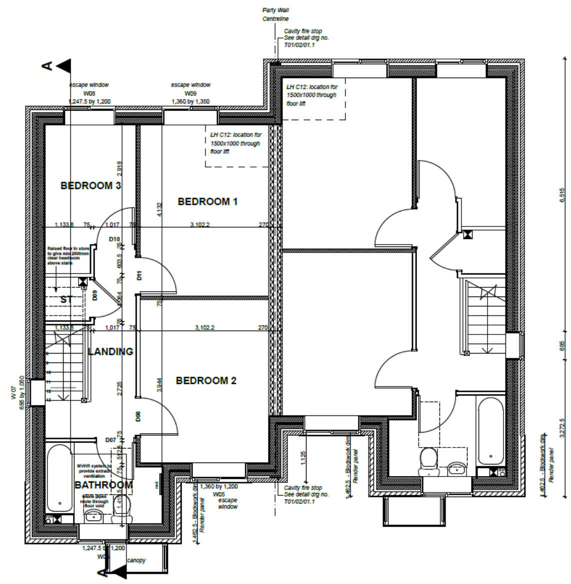


Figure 9: First floor plan

5. Construction details

Figure 10: Suspended concrete floor, and wall built to plinth block height

Figure 11: Construction of wall corner: brick finish to the right and the blockwork to be rendered

Figure 12: Door opening showing wall construction and insulated cavity closer

Figure 13: Party wall base; aerated blockwork plinth spanned by air membrane

Figure 14: Eaves under construction

Figure 15: View into loft showing insulation and structure

5.1 Continuity of floor insulation with external wall and at internal wall

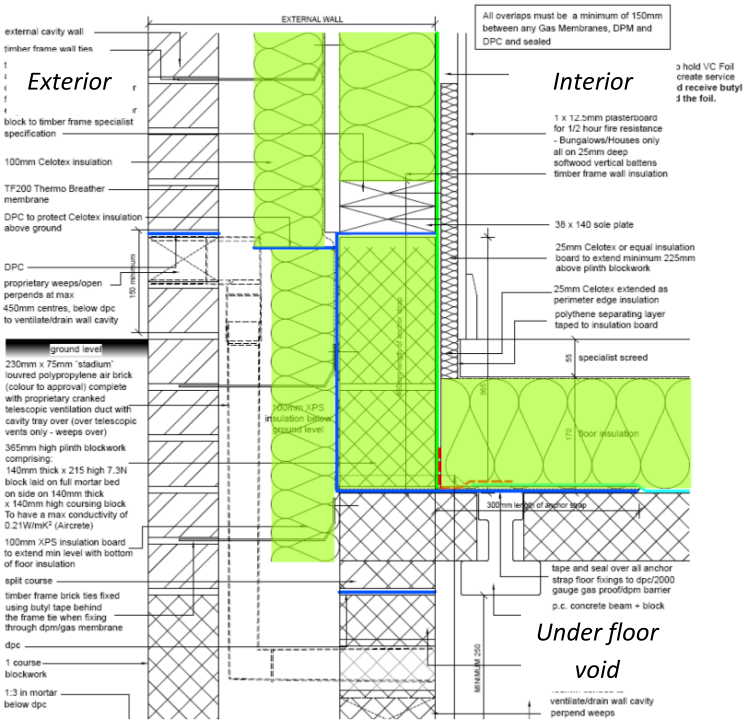


Figure 16: External wall and suspended ground floor junction

Ground floor construction

55 mm screed

170 mm PIR insulation

Block and beam suspended floor

Air barrier/DPM

Ventilated floor void

Wall construction

Plasterboard

25 mm service void

Air barrier/VCL

140 mm mineral fibre (k=0.32)

OSB board

100 mm PIR insulation

50 mm unfilled cavity

102 mm brick outer leaf

The floor was of suspended concrete construction with ventilated void beneath. See Figure 16 and Figure 10.

Continuity of insulation was ensured by the use of insulating aerated concrete blockwork at perimeter of floor and at the foot of load bearing internal walls – see Figure 17.

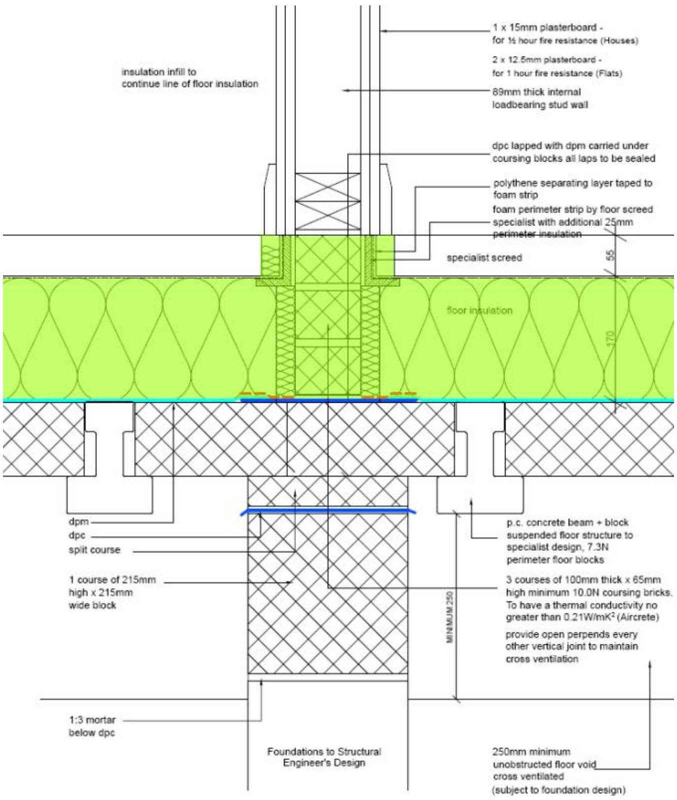


Figure 17: Internal load bearing wall

5.2 External wall construction

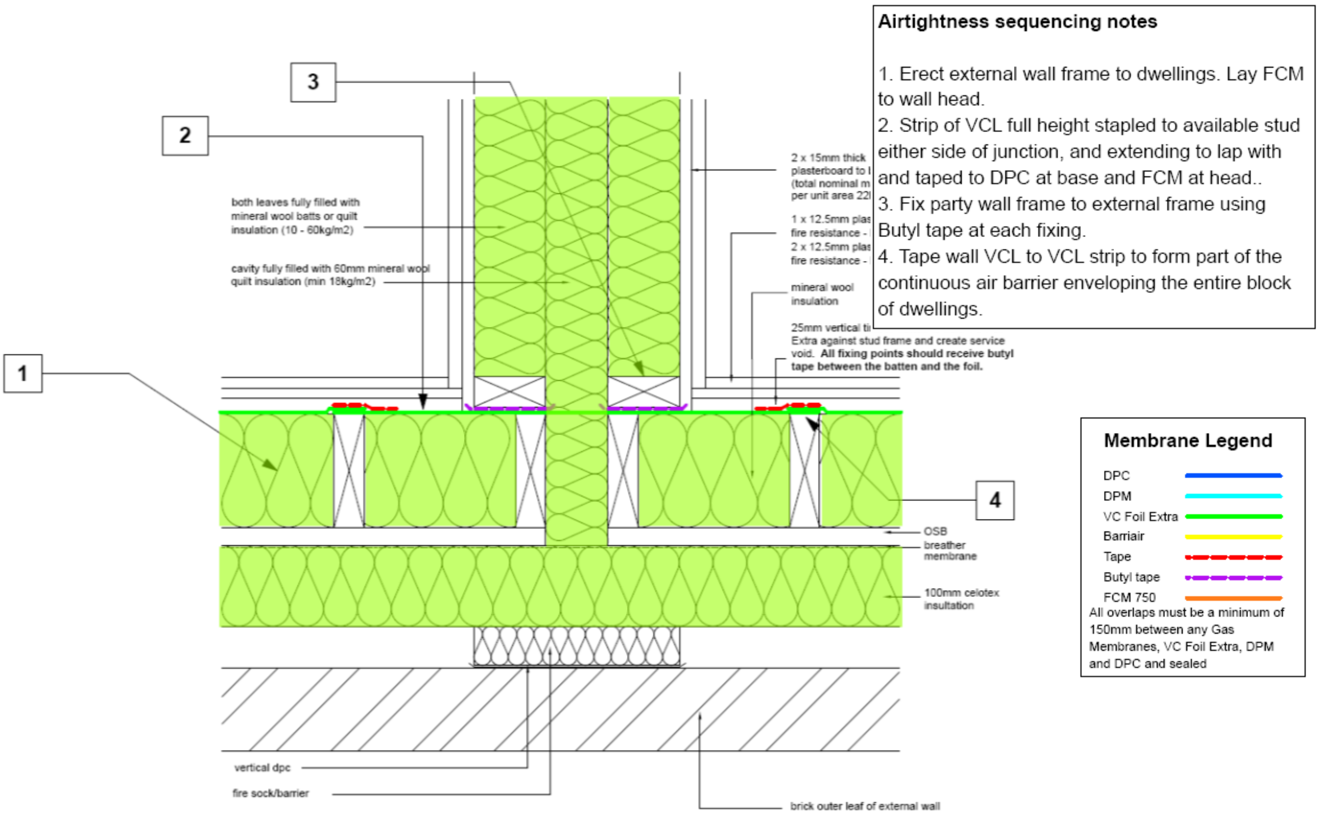
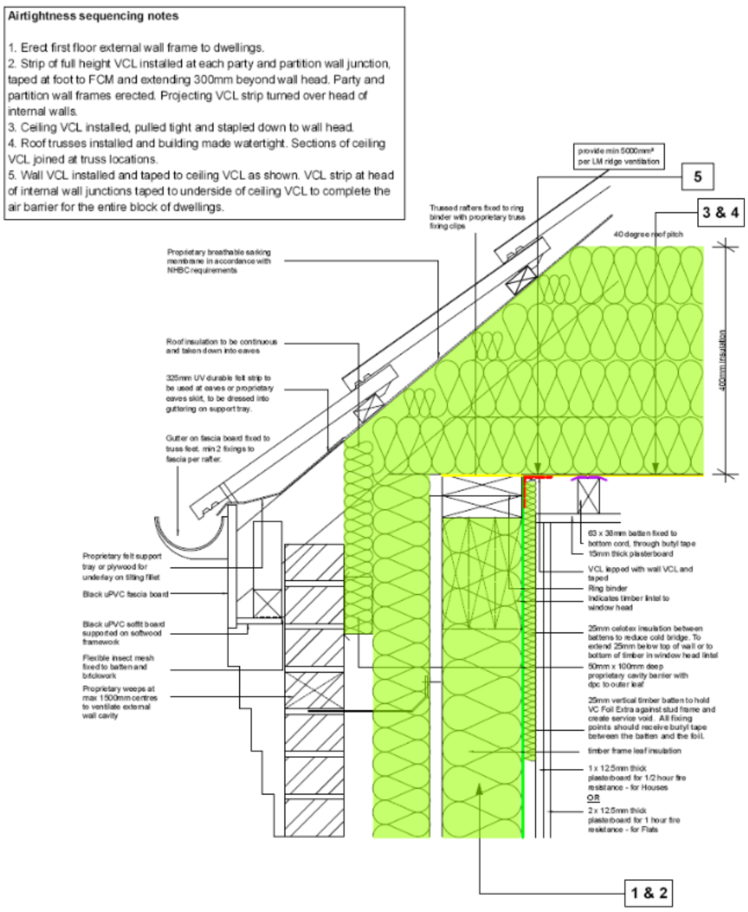


Figure 18: Party wall junction with external wall

Figure 18 is a plan detail illustrating the continuity of insulation at the junction of a party wall with an external wall. See also Figure 13: Party wall base; aerated blockwork plinth spanned by air membraneFigure 13. The same principle applies at the junction of internal wall with an external wall. In this case the internal wall does not require the same acoustic and fire performance, and therefore its construction is as illustrated for the partition wall in Figure 17.

Airtightness sequencing notes were added to these drawings to ensure that the contractor, who had not had previous experience of Passivhaus construction, achieved an effective and continuous air barrier. In the event it proved difficult to achieve the necessary airtightness with these details as designed. As a result the specification for the air barrier was amended to provide improved airtightness. This is described more fully in Section 6.

5.3 Roof construction



Roof construction

Plaster board

Services void

Air barrier/VCL

100 mm mineral fibre between joists

300 mm mineral fibre over joists

Roof space

Permeable roof membrane

Tiles on battens

At the junction with the wall additional insulation is included both on the warm and cold side to compensate for both the effect of the pitched roof and the conductivity of the timber members at the head of the wall. Thereby making this junction thermal bridge free.

See Figure 14 and Figure 15 for view of eaves and within the loft respectively.

Figure 19: Eaves detail

5.4 Window details

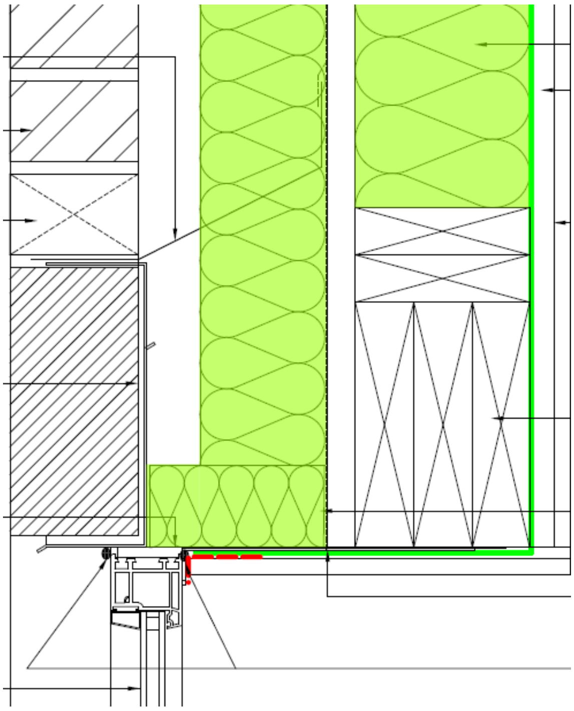


Figure 20: Head detail

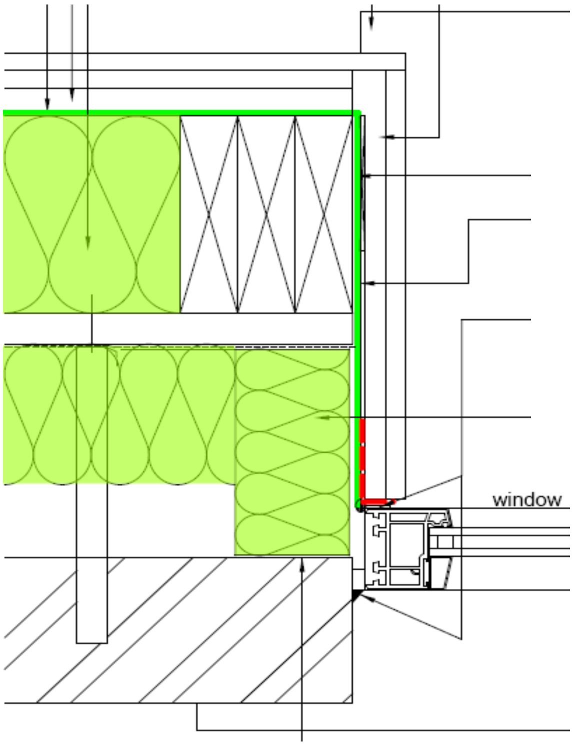


Figure 21: Jamb detail

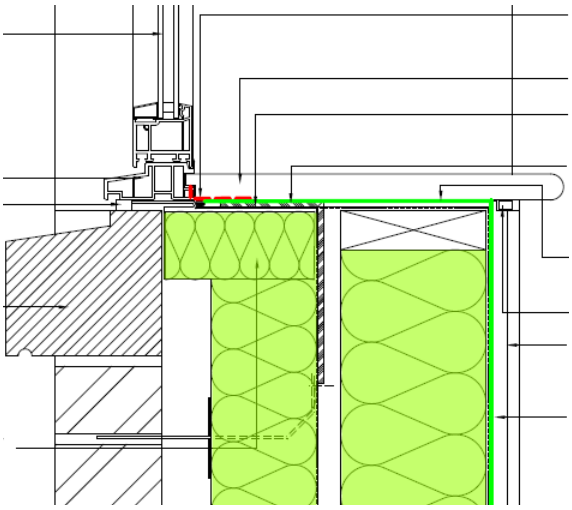


Figure 22: Cill detail

Figure 23: Window/wall air barrier junction

Note the use of independent lintels to brick outer leaf and structural timber frame, thereby avoiding the introduction of thermal bridging at head of wall. Cavities were closed by 150 mm wide insulated cavity closer to entire perimeter of window opening to ensure low psi values for the window installation.

Glazing specification

Frame	Munster Joinery, PassiV Future Proof, PH certified component-ID 0064wi03		
U_f-value frame	0.76 W/(m²K)	**Frame width**	102 mm
Ψ-glass edge	0.024 W/(mK)		
Glazing	Munster Joinery, Munster Passiv triple glazing 4/20/4/20/4		
U_g-value	0.57 W/(m²K)	**g-value**	0.61

6. Description of the airtight envelope and documentation of the air test result

Figure 24: First floor, airtight membrane passes through party wall

Figure 25: Airtight tape connects window frame to membrane

Figure 26: Membrane connected to airtight screed layer

Figure 27: Air test in operation

The original design of air barrier for the walls and first floor ceiling consisted of membrane fixed directly to the timber structure. This is joined to separate strips of membrane passing through the junction of external wall to internal partitions and party walls. There are additional strips extending the wall membrane to join to the floor damp proof membrane, thereby completing the airtight envelope for the building. However this arrangement of multiple membranes did not yield sufficient airtightness to meet the Passivhaus standard. The first few houses built on the site had an airtightness of approximately $1.5h^{-1}$ @50Pa. The details in section 5 show the original air barrier design.

To improve the airtightness the detail was changed. OSB board was applied to walls and first floor ceiling. The membrane was fixed in continuous sheets along the external walls with the party wall and internal walls being installed afterwards – see Figure 24. By having larger continuous areas of membrane and a firm surface against which to apply tape at the joints improved the quality of airtightness. The membrane was joined directly to the floor screed, which provided airtightness to the floor in this revised approach. This revised design enabled the houses subsequently built to achieve Passivhaus levels of airtightness. This experience enabled a contractor, previously without Passivhaus experience, to acquire the necessary skills to build to the standard. With their subsequent estate, detailing was further refined to the benefit of quality of the build.

19 and 21 Recreation Road was tested, on 15 June 2015, as a single building with a section of the party wall left incomplete to allow pressure equalisation between the two dwellings – see below for the results.

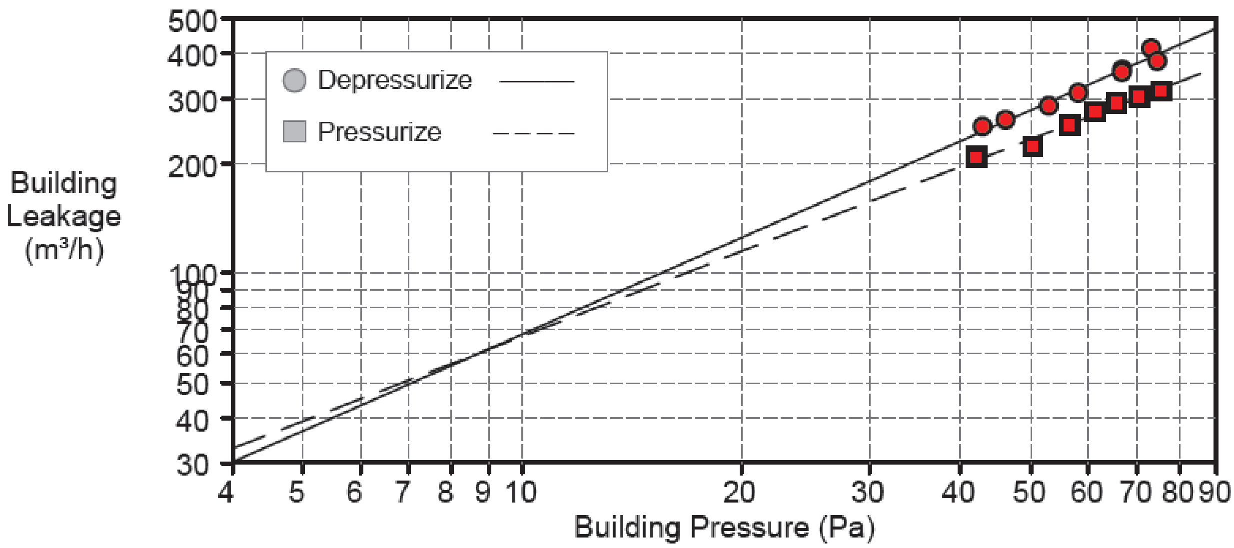


Figure 28: Air leakage graph

Air test result

Location	19 and 21 Recreation Road, Sandiacre
Date	15 June 2015
Undertaken by	Aeratech Ltd., Newark
n_{50} result	0.59 h^{-1}@50Pa

7. Design of ventilation ductwork

Figure 29: View inside plant room

Figure 30: MVHR unit with cover removed

Figure 31: Ductwork in intermediate floor void

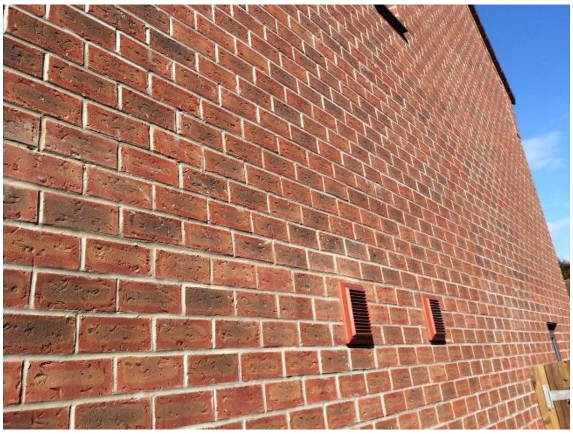


Figure 32: Intake and exhaust terminals

MVHR specification (one per house)

Model	Airflow, ValloPlus 270 SE, PH certified component-ID 0552vs03		
Heat recovery efficiency	84%	**Airflow range**	51–210m^3/h
Specific fan power	0.41Wh/m^3		

The unit has built-in frost protection. The advanced design of the frost protection system enables supply air to recover more heat and use less electricity than a traditional system. Its operation is illustrated in the diagram below.

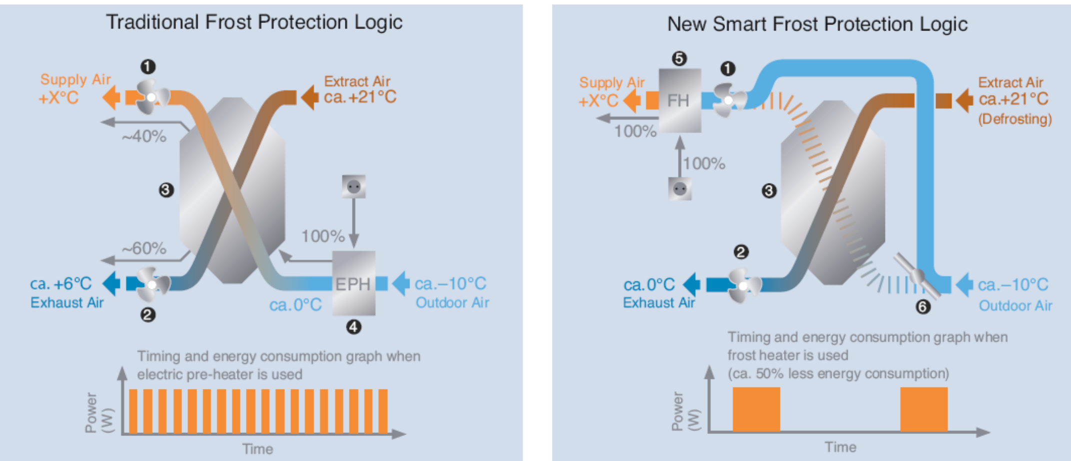


Figure 33: Operation of advanced frost protection system compared with a traditional one

The unit has a sophisticated range of options which are setup at the time of commissioning. Very little input from the tenant is required other than boost control when required. The bulk of heating is provided by a gas boiler and towel radiators with the unit's integral duct heater providing top up electrical heating as required. The accessible user controls are

- Boost on-off switches in the kitchen and the bathroom

Design flow rate (per house)

Room	V_{SU} (m³/h)	V_{EX} (m³/h)	$V_{THROUGH}$ (m³/h)
Kitchen		55	
WC		25	
Living Room	30		
Hall			50
Bed 1	30		
Bed 2	30		
Bed 3	30		
Bathroom		40	

The flow rates tabulated above have been designed to provide balanced whole house ventilation and to meet the ventilation requirements of UK building regulations. More air is being supplied to the upstairs rooms than is being extracted, and the balance, 50 m³/h, transfers down the stairs via the hall to the downstairs WC and the kitchen diner. See Figure 34 and Figure 35 for ductwork layout and valve locations.

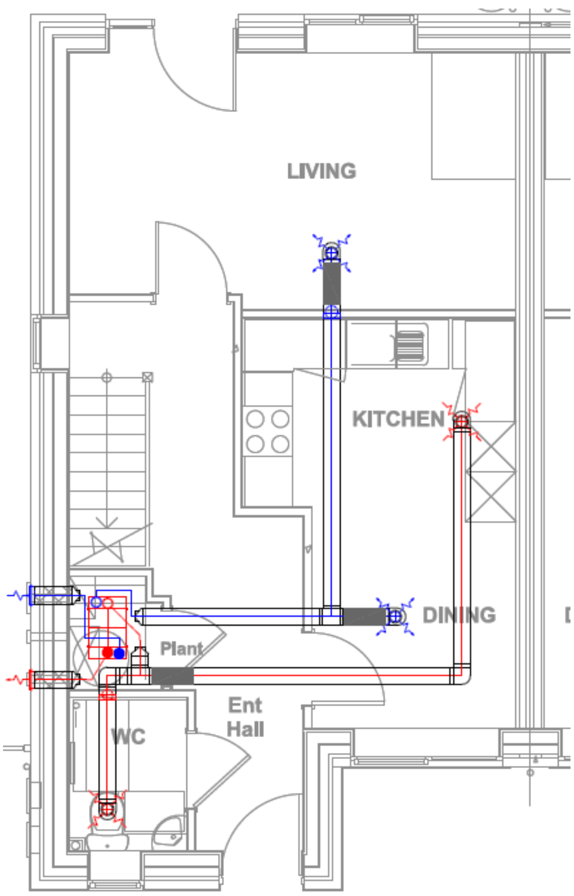


Figure 34: Ventilation system layout, ground floor plan

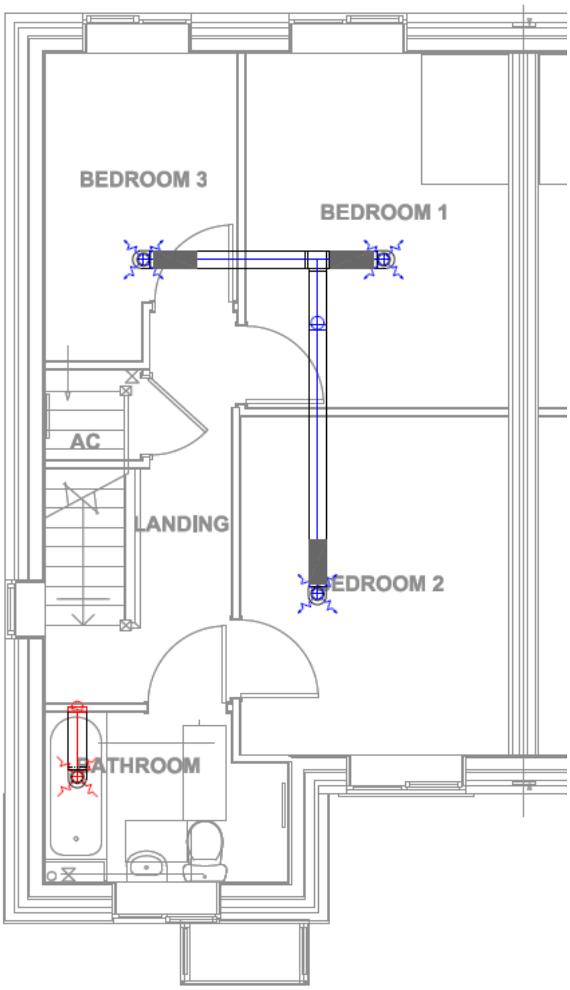


Figure 35: Ventilation system layout, first floor plan

8. Heat supply

Figure 36: Boiler in upstairs store room

Hot water and space heating is supplied by a gas combination boiler. This type of boiler is very common in the UK. Hot water is direct from the boiler, being generated on demand. There are two radiators per house in the form of heated towel rails in the bathroom and WC – see Figure 6. Only when these do not met demand does the electrical duct heater activate. The heating system is controlled by

- A thermostatic programmer in the hall

Boiler specification (one per house)

Model	Worcester Bosch, Greenstar 28i Junior Combi Mk V condensing boiler		
Boiler output	24 kW	**SAP 2009 Seasonal Efficiency**	84%

9. PHPP calculations

Specific building demands with reference to the treated floor area					
	Treated floor area	174.9	m²	**Requirements**	**Fulfilled?***
Space heating	Heating demand	**17**	**kWh/(m²a)**	15 kWh/(m²a)	-
	Heating load	**10**	**W/m²**	10 W/m²	yes
Space cooling	Overall specif. space cooling demand		**kWh/(m²a)**	-	-
	Cooling load		**W/m²**	-	-
	Frequency of overheating (> 25 °C)	2.9	%	-	-
Primary energy	Heating, cooling, dehumidification, DHW, auxiliary electricity, lighting, electrical appliances	**117**	**kWh/(m²a)**	120 kWh/(m²a)	yes
	DHW, space heating and auxiliary electricity	78	kWh/(m²a)	-	-
	Specific primary energy reduction through solar electricity		kWh/(m²a)	-	-
Airtightness	Pressurization test result n_{50}	**0.6**	**1/h**	0.6 1/h	yes

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

Passive House?	yes

Figure 37: PHPP important results

9.1 Heat balance

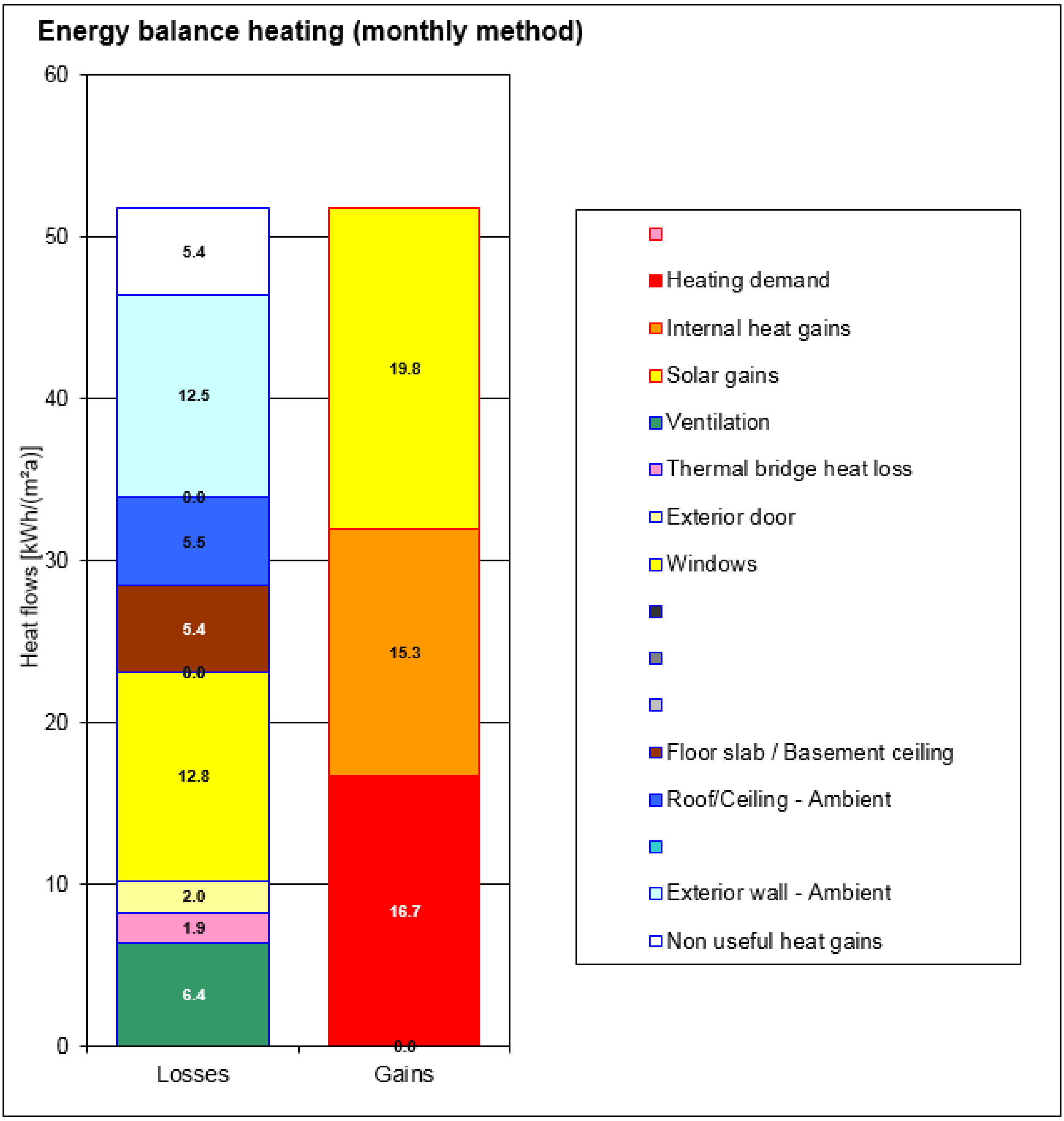


Figure 38: Heat balance

The Heat balance according to PHPP monthly method is illustrated in Figure 38. This shows that the required annual heat is provided by solar gains, internal heat gains and heating in approximately equal proportions. The greatest heat losses are through the walls and windows. The latter being more than offset by the solar gain through the windows.

10. Construction costs

Achieving a low cost was a challenge in this project. As social housing these dwellings needed to be rented or sold at affordable rates. Therefore the increased cost due to higher fabric specification needed to be offset by capital and lifetime savings. The cost of a complete wet central heating system was saved by using the ventilation system to distribute heat supplemented by towel rails in the bathroom and WC. The resulting low energy bills contribute greatly to the affordability of living in these units.

The cost for construction alone, cost categories 300 to 400, was £938/m² (€1,100/m² based on current exchange rates), as tendered in August 2012. Area is gross internal floor area.

11. Post occupancy evaluation at 19 and 21 Recreation Road, Sandiacre

There has been no monitoring of internal conditions or collection of meter readings at this property following occupation. The occupants are housing association tenants.

MEAD: Energy & Architectural Design Ltd
3 Harvey Road
London
N8 9PD

Authorised by:
Passive House Institute
Dr. Wolfgang Feist
Rheinstr. 44/46
D-64283 Darmstadt

Certificate

Mead: Energy & Architectural Design Ltd awards the seal "Certified Passive House" to the following building

No. 19 & 21 Recreation Road, Sandiacre, Nottingham

Certified Passive House
Passive House Institute

Client: **emh homes**
Memorial House, Stenson Road, Coalville, LE67 4JP

Architect: **Halsall Lloyd Partnership**
53 Forest Road East, Nottingham, NG1 4HW

Building Services: **Encraft**
Brandon House Courtyard, William Street, Leamington Spa
Warwickshire, CV32 4YS

This building was designed to meet Passive House criteria as defined by the Passive House Institute. With appropriate on-site implementation, this building will have the following characteristics:

- Excellent thermal insulation and optimised connection details with respect to building physics. The heating demand or heating load will be limited to
  15 kWh per m² of living area and year or a heating load of 10 W/m², respectively
- When outdoor temperatures are high, thermal comfort can be ensured with passive solutions or with minimal energy demand for cooling and dehumidification according to the location-specific Passive House requirements.
- A highly airtight building envelope, which eliminates draughts and reduces the heating energy demand: The air change rate through the envelope at a 50 Pascal pressure difference, as verified in accordance with ISO 9972, is less than
  0.6 air changes per hour with respect to the building's volume
- A controlled ventilation system with high quality filters, highly efficient heat recovery and low electricity consumption, ensuring excellent indoor air quality with low energy consumption
- A total primary energy demand for heating, domestic hot water, ventilation and all other electric appliances during normal use of less than
  120 kWh per m² of living area and year

This certificate is to be used only in combination with the associated certification documents, which describe the exact characteristics of the building.

Passive Houses offer high comfort throughout the year and can be heated or cooled with little effort, for example, by heating/cooling the supply air. Even in times of cold outdoor temperatures the building envelope of a Passive House is evenly warm on the inside and the internal surface temperatures hardly differ from indoor air temperatures. Due to the highly airtight envelope, draughts are eliminated during normal use. The ventilation system constantly provides fresh air of excellent quality. Energy costs for ensuring excellent thermal comfort in a Passive House are very low. Thanks to this, Passive Houses offer security against energy scarcity and future rises in energy prices. Moreover, the climate impact of Passive Houses is low as they reduce energy use, thereby resulting in the emission of comparatively low levels of carbon dioxide (CO_2) and air pollutants.

issued: 06.01.2016

Kym Mead,
MEAD: Energy & Architectural Design Ltd,

Certificate-ID: 12793_MEAD_PH_20160119_KM