AECB

the sustainable building association

Low Energy Case Study - Ross-on-Wye by David Olivier

Introduction

This project was designed in 1997-99 and constructed in 2000. It is a custom-designed 249m^2 detached house on an infill plot in a historic small market town. An attached unheated garage, workshop and storage space are provided to the north of the house, outside the thermal envelope but integrated into the form of the house. The house is mainly two-storey and partly one-storey, with most of the important rooms facing almost due south.

The house is next door to the owners' previous three-storey Victorian house, which had a large garden of over 3,000m^2. Planning permission was gained to subdivide this area of land and to erect a new house with its own separate access from the end of a nearby cul-de-sac. The street scene is typified by detached houses of different ages, on large plots, with many groups of mature trees. It is classified as within the Wye Valley Area of Outstanding Natural Beauty and is a relatively short walk from Ross-on-Wye's historic town centre. All normal mains services are available on the site.

The owners initially told Hook Mason (HM) that they would like an energy-efficient house which was simple to operate and which had reduced running costs. HM had previously had little experience of this type of building and the project architect left the practice soon after the clients moved in.

Several design proposals were produced, although the owners initially felt that energy efficiency could be emphasised more and requested the architects take advice from outside the practice. The final shape and floor plan were settled in late 1999, a contractor was appointed and the owners moved in during late November 2000.

All the principal living rooms face almost due south and are contained within a long, thin two-storey structure. The living room, dining room, home office, kitchen and principal bedrooms all receive high levels of passive solar gains. Some subsidiary spaces on the ground floor, such as a utility room, a WC/shower room and a music room are still within the thermal envelope but are situated to the north of this main structure.

Construction

The house was constructed some time after earlier low-energy housing projects such as the Reyburn House, Embleton House, Lower Watts House, the Autonomous House, Southwell and several projects by Vale and Vale Architects in Sheffield and Nottingham. Profiles of these had appeared in BRECSU's General Information Reports 38-39 in 1995. Nevertheless, there was some resistance to suggestions of replicating the measures applied on these earlier projects, examples of these measures being:

- A solid first floor - for its better airtightness.
- Scandinavian wood-frame (or aluminium-clad wood) low-e triple-glazed windows - for their good energy performance and value-for-money.
- A fully-filled cavity with at least 150mm mineral fibre - this level was considered well worthwhile for the energy saving.
- No masonry returns as this was a source of thermal bridging.

Following lengthy discussions over levels of energy efficiency, the final specification chosen was:

- A 125mm fully-filled cavity.
- A timber first floor.
- Swedish low-e double-glazed aluminium and wood composite windows, although the patio doors are triple-glazed.
- A partial thermal break at the jambs of the window reveals, although with nearly as good an R-value as the adjoining wall insulation.

The architects considered these to be necessary compromises in order to make the house more economical to build. The makeup of the timber-clad wall was not materially changed; its construction was not considered problematic. Nor was the design of the roof significantly changed.

Thermal Envelope Details

Ground floor

Carpet, 100mm ground-supported concrete slab, DPM, 100mm EPS insulation, blinded hardcore. As the local soil is a coarse sandy loam, the floor U-value would be lower than the average for this level of floor insulation.

First floor

Solid timber joists, supported on joist hangers and also with several steel beams. An attempt was made to seal the area between the joists using a strip of polyethylene membrane, the same material as is used to make the roof airtight. This membrane is trapped beneath the plaster on the external walls above and below the joist zone. The continuity of the membrane is inevitably interrupted by the joists themselves.

External walls

(1) Wall type 1: cavity wall with brick outer leaf; fair-faced concrete block outer leaf below plinth level. Separate lintels are used, in order to avoid a severe thermal bridge at the window head. The masonry returns are broken by 50mm of PU foam insulation.

At the time, full masonry returns were standard in the UK. One-piece pressed steel lintels are still normal, even in 2009. So although the changes were less than suggested, they still represented quite an improvement on UK practice. The house as-designed or as-built appears to be significantly ahead of the 2006 Building Regulations Part L1.

From inside: 13mm dense plaster, 100mm dense concrete block, 125mm ‘Dritherm’ mineral fibre slab with stainless steel wall ties, 100mm clay brick or 150mm fair-faced concrete block below plinth level. U-value = 0.27W/m^{2}K.

(2) Wall type 2: Externally-insulated wall with timber cladding. In effect, an ‘inside-out’ masonry-clad timber-frame wall. From inside: 13mm dense plaster, 100mm dense concrete block, 100mm mineral fibre between 50 x 100mm softwood studs on 600mm centres, followed by 100mm mineral fibre between a similar layer of studs at right angles, OSB sheathing, breather membrane, 25mm cavity with vertical battens, timber cladding projecting beyond the brickwork below. U-value = 0.24W/m^{2}K. About 45 (55)% of the wall area is of type 1 (2).

Roof

Tiles, felt and battens, breather membrane, 300mm deep OSB-webbed I beams on 600mm centres, filled with 300mm mineral fibre. Polyethylene membrane for airtightness, sealed well at seams and sealed to the plaster on the walls. Plasterboard, skim coat of plaster. No electrical wiring penetrates the membrane. U-value = 0.14W/m^{2}K.

Windows

Swedish aluminium and softwood composite windows, with 12mm argon-filled low-e double glazing. U-value = 1.6W/m^{2}K. In order to raise the level of passive solar gains, a high proportion of the total window area faces south. As the elevation shows, the house has a large amount of glass on the south facade. The south window area is equal to around 16% of the house’s total floor area.

Opaque doors

Timber, made locally by a joiner, 25mm PU foam in the door leaf. U-value = c. 1.2W/m^{2}K. Estimated for a fully opaque door.

Rooflights

One, with 12mm argon-filled low-e double glazing. The energy consultant had recommended using vertical windows wherever possible, on north and south, to reduce the risk of summer overheating. Vertical windows are more easily shaded. The rooflight on the utility room is not a great summer overheating risk though as it faces north and is also shaded from the south by the two-storey portion of the building.

Air leakage

The air permeability has not been measured. The original aim was to meet a figure of no more than 1ac/h@0Pa. Most of the recommended construction details were consistent with reaching this figure. Because not all of the suggestions were adopted, and given that the contractor needed considerable support in order to understand the energy-efficient aims of the project, it is possible that the measured air permeability would be higher.

Space and Water Heating

Ideal Response SE fanned flue combination gas condensing boiler was chosen, supplying radiators. Conventional UK controls, ie. a combination of an overriding room thermostat and individual TRVs on standard panel radiators. There were no radiators in the kitchen, in one small bedroom or in the bathroom above the kitchen.

A glass-fronted fireplace in the living room, with an air supply direct into the firebox. This appliance is used about five times a year to burn small amounts of wood. It was sealed as well as possible from the rest of the house. A relatively compact hot water plumbing system for such a large house. The first floor bathroom and the two shower rooms are directly above the kitchen.

Space Cooling

No active cooling system. In summer, the MVHR system is turned off and the house relies on natural ventilation; ie. opening windows at low and/or high level. Usually, the north-facing landing windows and the utility room rooflight are used for this purpose. To provide summer ventilation in the internal bathrooms, PIR controls briefly turn on the whole MVHR system when a bathroom or WC is in use.

The kitchen windows face due south. Internal blinds are used on these windows when working in the kitchen during summer. These blinds were installed after one season in order to reduce the daylight levels in sunny summer weather.

Cooking

Gas hob and electric oven.

Electrical Appliances

Energy-efficient models, as far as possible.

Lighting

Virtually all fluorescent, except for a few incandescent lamps on tracks.

Measured Energy Consumption and CO_2 ERmissions

The owners have tried to read the meters at monthly or two-monthly intervals since handover in November 2000. Gas consumption in the first 11 months was clearly elevated; this is likely to be due to drying-out.

Figure 1. Average Energy Consumption, October 2001 to October 2009

Form of energy	*Purpose*	*Usage kWh/m²yr*
Gas	*Space and water heating and cooking*	*51*
Electricity	*Lights, appliances, ventilation and heating system pumps, fans and controls*	*15*
Total		*66*

Figure 2. Greenhouse Gas Emissions

Form of energy	*Emissions Coefficient kg/kWh*	*CO2 Emissions kg/m²yr*
Gas	*0.206*	*10.5*
Electricity	*0.61*	*9.2*
Total		*19.7*

NOTE: The coefficient used above applies to low-voltage loads, such as the domestic sector. The UK-wide average is 0.59kg/kWh. For those loads which are supplied at high voltage, such as factories and railways, the figure would be correspondingly lower than 0.59kg/kWh.

One of the house's larger consumers of electricity is the MVHR system. Systems with ECPM motors were available only with difficulty in 2000. The system chosen uses over 200W at its peak airflow rate; i.e. when bathing or cooking is in progress. A modern system in 2009, using DC motors, could be expected to use as little as 75W for this size of house and might reduce the house's electricity consumption by up to 5kWh/m^2yr. The owners plan to experiment with turning down the MVHR system further in winter, given the low occupancy.

Cost

The house cost approximately £1,000 per m^2 floor area in 2000, including external works and landscaping

Experience/Feedback

Some work was not done to a sufficiently high standard initially. It had to be taken down and replaced. The clients observed this process from their Victorian house which overlooked the building site. Not all of these problems were noticed at the time. In particular, the roof air barrier as constructed was not fully-sealed and continuous. The builders omitted a crucial small portion of membrane in the area of roof around the soil vent pipe (SVP). The result of this omission was a small rectangular patch of prematurely-melting snow in winter weather. This can be seen on the early photograph of the finished house, on the south slope of the roof, near the ridge. See Figure 1. Remedial work was needed. Since then, the snow has not melted prematurely around the SVP. Air leakage has clearly been reduced. In the circumstances, it could have been beneficial to spread construction over a slightly longer timescale. This would have taken account of the builder's unfamiliarity with the basics of energy-efficient design and the fact that a rapid learning process was underway.

The externally-insulated timber-clad wall, with 200mm insulation, was significantly easier to construct to a high thermal standard than the masonry-clad cavity wall with 125mm insulation. This point has already been observed and commented on in relation to other UK projects.

Since finishing the house, the importer of the Swedish windows has gone out of business. Replacement of any parts which fail could become a problem.

The Ideal condensing combination boiler has been temperamental. The expansion vessel needed replacement after a couple of years.

Several of the fluorescent light fittings specified by the architects, which use 'Thorn 2D' lamps, have failed and needed total replacement. This does not seem altogether satisfactory. In 2000 they were significantly more expensive than alternative fittings which took incandescent lamps. Also, at that time, most other CFLs were of European origin and were well-made, with few premature failures.

The Swedish MVHR system works well and the owners are very pleased with it. It is quiet and unobtrusive. The heating system, which is representative of today's UK practice with condensing boilers, has given reasonable but not perfect temperature control.

The owners do not consider that the house has ever overheated in summer. There have been two noticeably hot months since its completion; ie. August 2003 and July 2006. It appears that the relatively high thermal mass, the lack of west-facing glazing and the provision for natural ventilation, using the stack effect, have contributed to the satisfactory conditions.

As noted earlier, the kitchen faces due south and internal blinds were installed on the windows in late 2001, after one season of living in the house. The primary reason for doing this was in order to reduce daylight levels in sunny summer weather. It also had the side-effect of considerably reducing the radiant solar heat gain.

Having now lived in the house for some years, the owners are considering investing in electricity-generating renewables - possibly photovoltaics. This is under review. An energy adviser has suggested that other measures open to them could possibly save the emission of more greenhouse gases for each £ spent.