Low energy cottages

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Robert and *Brenda Vale* report on the design and construction of a pair of low energy cottages in North Sheffield which had to contend with more than just the design restrictions.

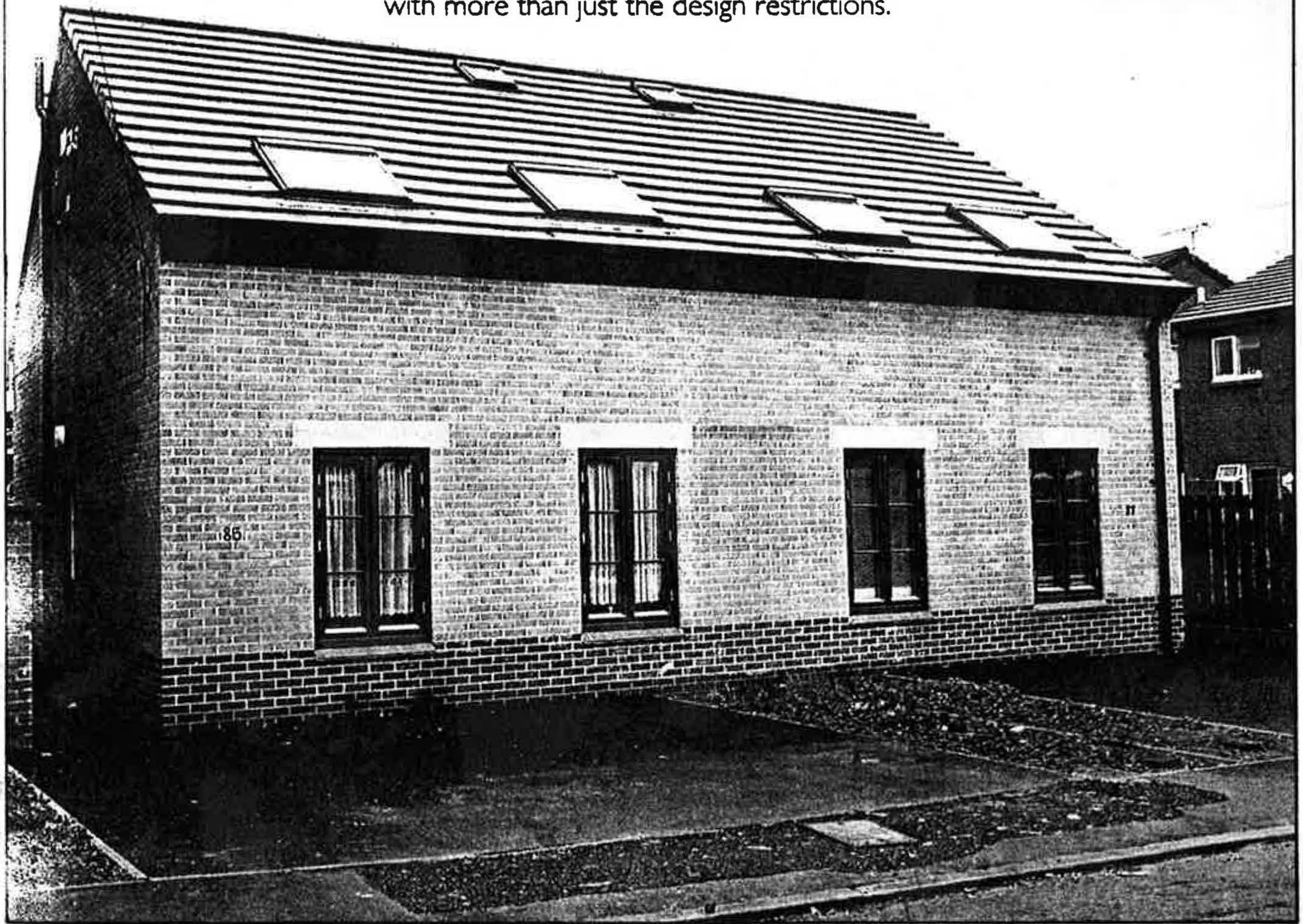


Photo: Paul Horner

The initial approach to the architects by the development worker at the North Sheffield Housing Association was very straightforward: "Low income tenants have difficulties in finding enough money to keep warm. We want you to design us a pair of very low energy houses as a prototype for infill sites." The architects accepted enthusiastically. Then came a series of qualifying conditions. "You will have to build to a standard Housing Corporation budget," he added. The architects agreed. "The site has the remains of cellars on it from demolished houses, so the foundations will need to be deep," he pointed out. Then came the final shot in his locker, "We've spent 15% of the architects' fees on an in-house site investigation ...." By this time the architects were hooked, and agreed to carry on regardless.

Design intentions

The above catalogue of problems formed an important part of the design strategy for approaching the project, but the inspiration for the design as a whole was the series of low cost cottages designed by a number of well-known architects at the start of the 20th century. These were a response to the very real perceptions of the general population's housing need. The best known of these designs were those submitted for the cheap cottages competition at Letchworth[1]. The successful competition designs used a combination of formal simplicity with technical ingenuity to reduce cost.

The starting point for the design of the ecological cottages was the size of the site, wide enough to allow a pair of semi-detached houses with a passage down each side. A common pattern for houses in Sheffield is to have the front door in the side, allowing rooms to occupy the full width of front and rear elevations. This was the approach adopted.

A lobby with space for two doors each side (to allow possible sub-division of front and back rooms) and a winding stair with wc underneath, formed the central core of each house on the ground floor. Above, the space was a mirror image, allowing division into a maximum of four bedrooms, two single and two double, with a bathroom above the entrance lobby.

The symmetrical plan reflected both simplicity of form and economy of span, and also the Housing Association's desire to provide houses suitable for tenants of Bangladeshi background, whose cultural requirements were for a separate women's room and men's room on the ground floor. The site orientation was such that the southerly direction was towards the street, meaning that, in the interests of privacy, it was not appropriate to design a direct gain passive solar solution with large windows. However, the research for the Pennyland project at Milton Keynes showed that the orientation of a conventional house north-south rather than east-west could produce much greater energy gains than those achieved by the further concentration of the glazing on the south side of a south facing house[2]. The cottages as designed were conventional houses facing north-south.

The simplicity of the plan was carried through to the section, but to reduce the built volume, and therefore reduce the cost, the first floor rooms were formed in the roof, with the front and back walls being only 1500 mm high. This was the minimum dimension that the Housing Corporation would permit if the full floor area was to be counted as habitable space. In the first version of the

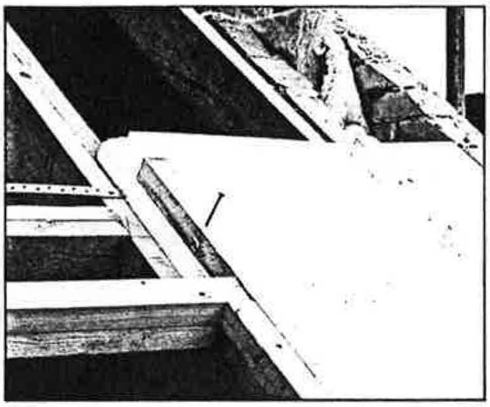
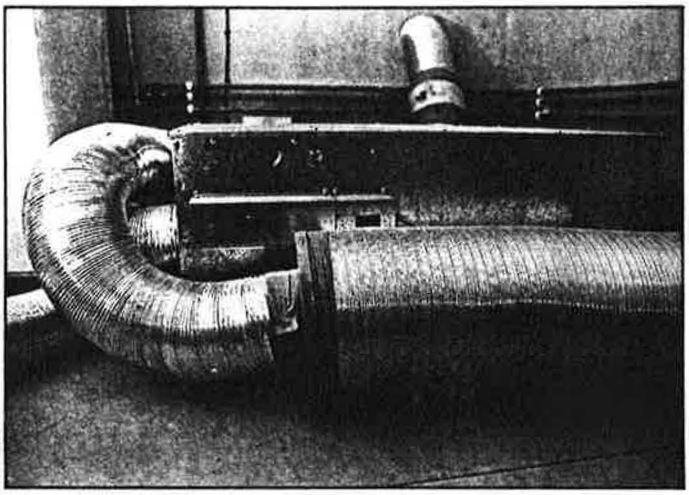


Photo: Brenda and Robert Vale

Above: The roof has a U-value of 0·13 W/m^{2}K achieved through 200 mm of fibreglass and 50 mm of expanded polystyrene.

Below: Mechanical heat recovery has been provided to reduce ventilation heat losses.



design this dimension was 1200 mm, which gave a better view out of the roof windows.

Detailed design

The cottages were intended from the outset to be superinsulated and to have mechanical heat recovery ventilation to reduce ventilation heat losses. Locations for the necessary ducting were incorporated so that duct risers became part of the staircase and horizontal runs fitted above bedroom doors. All the other aspects of energy performance were achieved by adaptations of the building fabric.

A key aspect of the design was the intention to use construction methods that would appear conventional to a contractor. There is a cavity wall, a concrete ground floor and rafter roof; the only differences are in the amount of insulation built into each element. This approach, developed over several years by the architects, seems to lead to competitive tender prices, because there is no unfamiliar technology involved, as there might be with, for example, prefabricated timber-framed insulated panels. The insulation values of the various elements of the cottages are given in table 1.

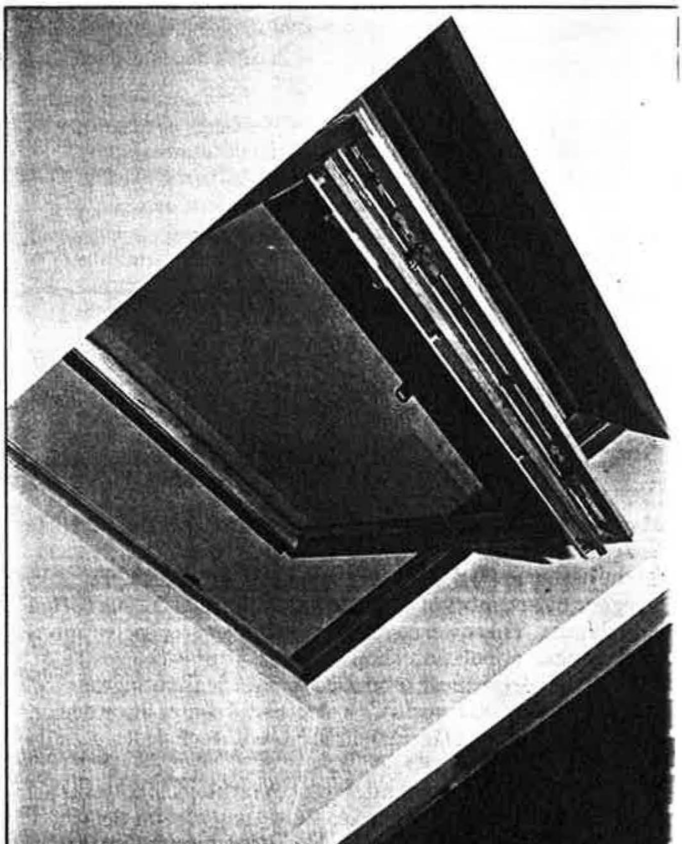
Heating and ventilation

The design of the houses was intended from the outset to incorporate a mechanical heat recovery system for ventilation, so as to allow fresh air without draughts. The expanded aluminium ducts were boxed-in in places where they would seem part of the house rather than uncomfortable additions, and the fan unit, heat exchanger, pollen filter and silencer were installed in a plant space on top of the first floor bathrooms. The machine used was from Wickes, the DIY store, because it was cheap and easy to replace. The ventilation rate is controlled by a rheostat in the kitchen that is set as required by the tenant.

The plantroom in the roof also accommodates the combi boiler, used to avoid the heat loss from a cylinder of stored hot water. The calculated boiler size is 1·7 kW at 25 K temperature difference, and the boiler has been set to this low output. Radiators are conventional but oversized, to allow use of a condensing boiler when the present one wears out. Only one suitably sized condensing combi boiler could be found at the time of construction, and it proved too expensive in capital cost. All radiators have thermostatic valves.

The full central heating system is really not necessary, a couple of gas fires would provide more than enough heat, but the architects were anxious that the tenants should not have houses which seemed in any way cheap. One way of making it apparent that they were getting a proper house was to provide a proper central heating system. Using the BRE's BREDEM model, the houses show a calculated energy reduction of 83%, compared with the same design built to the current *Building Regulations*.

Below: Windows are triple-glazed, gas-filled with a low E coating. The result is a U-value of 1·2 W/m^{2}K.



Total predicted fossil fuel space heating demand is about 1500 kWh/y, bringing space heating into line with domestic hot water as an energy load. The houses each have an internal floor area of 88·4 m^2, and cost £91 000 for the two including all site works and drainage.

Other considerations

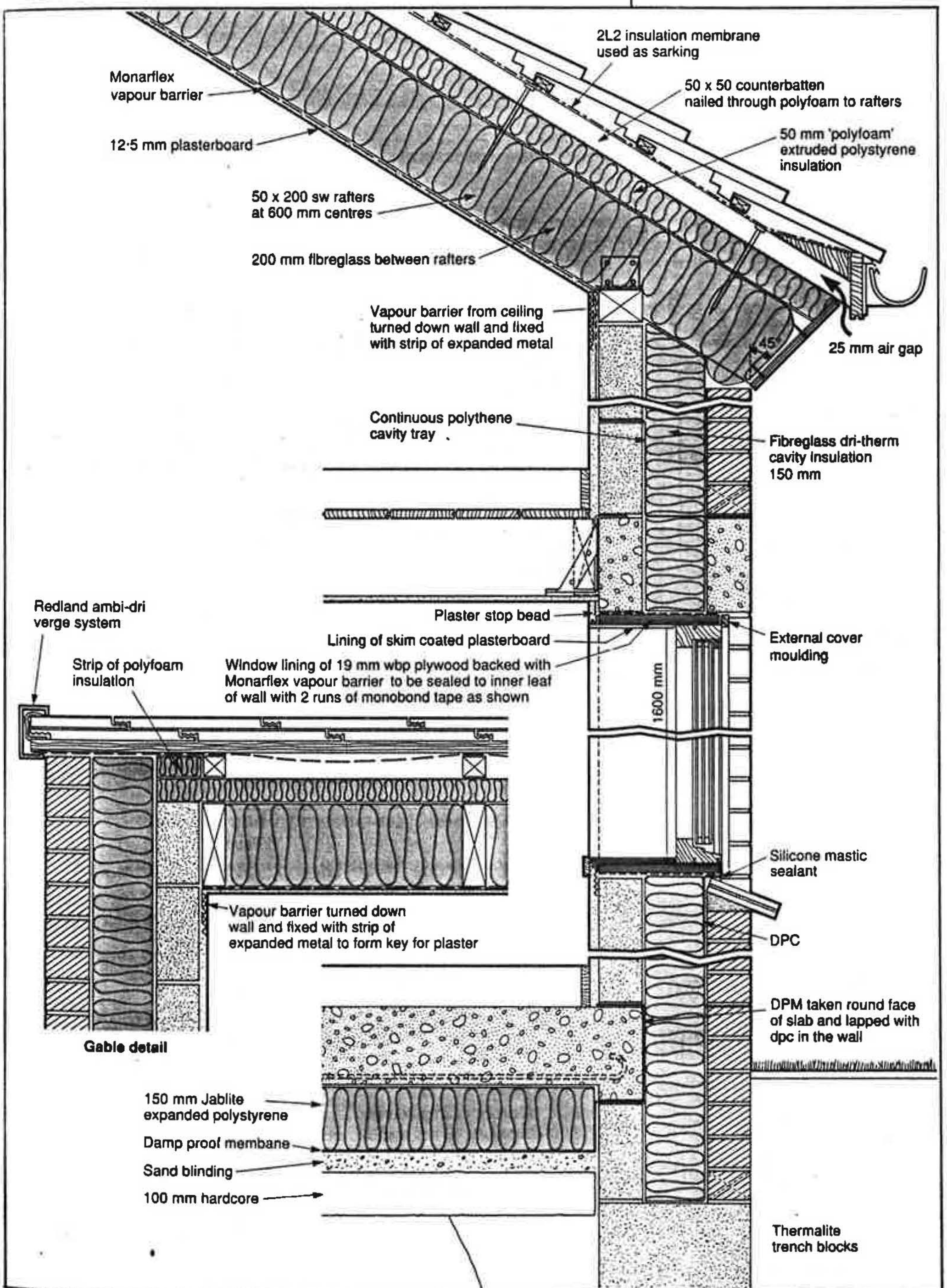
The architects remain convinced that the primary goal in so-called green architecture must be to reduce fossil fuel energy demand.[3] To worry about anything else before tackling energy is like rescuing goldfish from the garden pond while your house is burning down. However, having minimised the energy demand through the use of superinsulation and compact electronically ballasted light bulbs, it did seem appropriate to try to tackle some of the other concerns which might appear under the green umbrella.

Naturally timbers from non-sustainable sources were not specified, and insulation materials known to use cfcs in their manufacture were avoided. An attempt was also made to avoid particle boards and the accompanying formaldehyde emissions into the house.[4] Data on the emission of gases from boards are not easily obtained, but it was reasoned that the use of softwood cored blockboard would be better than chipboard or plywood, because the proportion of wood to glue would be higher. Therefore, the kitchen cupboards, wardrobes and hall cupboard were made to the architects' designs by the contractor.

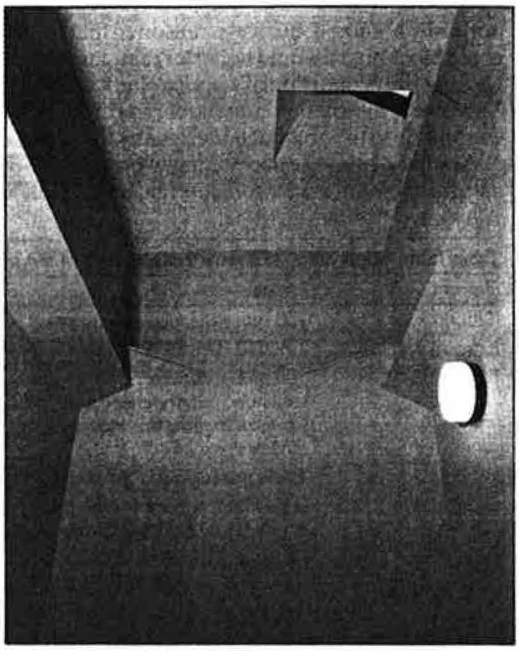
Similarly, vinyl floor coverings were avoided in favour of natural linoleum made from jute and linseed oil. Water based

Table 1: Insulation values of the various elements of the cottages

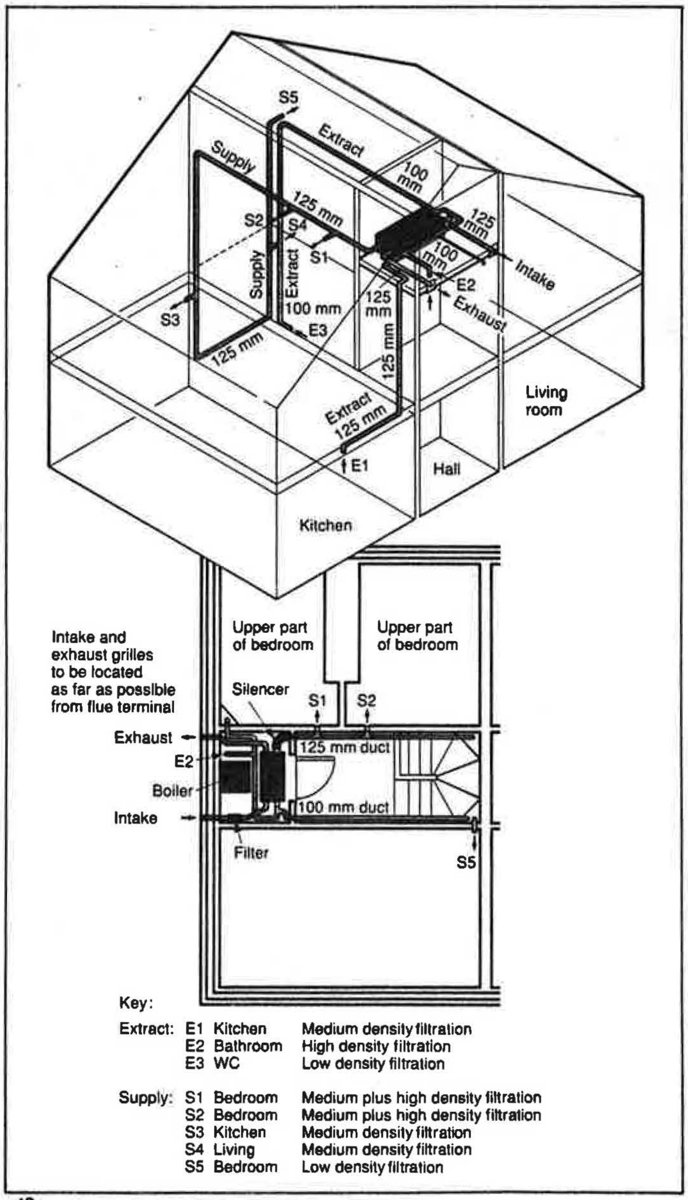
Element	Insulation	U-value (W/m^2K)
Ground floor	150 mm expanded polystyrene	0·20
External wall	150 mm resin-bonded glass fibre	0·20
Roof	200 mm glass fibre, 50 mm expanded polystyrene, 8 mm foil-faced bubble film allowing for cold bridging	0·13
Windows	Triple glazed, low E, gas-filled	1·20
External doors	Steel-faced, polystyrene-filled, gas-filled low E double glazing	1·00
Ventilation	Mechanical with heat recovery	0·2 ac/h



Left: Conventional construction methods have been used; the only differences are in the amount of insulation built into each element.



Above: Minimising the energy demand has been the priority but other green concerns have been tackled. Here water-based non-vinyl emulsion went on the walls.



non-vinyl emulsion went on the walls. The budget would not stretch to the new organic paints imported from Germany.

Energy issues were not limited to the consumption of the building in operation. A serious attempt was made to use materials that did not require large amounts of manufacturing energy, producing a 'wholemeal' architecture of largely unrefined 'low energy' materials such as timber for floors and roof, and concrete for ground floor, roof tiles, internal partitions and facing bricks. The concrete walls and floor slab surrounded by thermal insulation, give a high thermal mass to the cottages, and concrete facing bricks use less energy to manufacture than fired clay bricks.[5]

Conclusions

The ecological cottages in Sheffield demonstrate once again that low energy design need not cost any more than conventional design. The Housing Association received no extra funding for its construction other than the normal support from the Housing Corporation. The question that remains is how often must the case be proven before the ideas are taken up on a wider scale?

Further reading

[1]"The book of cheap cottages exhibition", The Country Gentleman and Land and Water Ltd, 1905.
Weaver, L, "The Country Life book of cottages", Country Life Library, London, 1919.
[2]Everett R, "Passive solar in Milton Keynes", *Research Report ERG031*, Energy Research Group, Open University.
[3]Vale B and R, "Green Architecture", Thames and Hudson, London (1991).
[4]Curwell et al, eds, "Buildings and health: The Rosehaugh Guide to the design, construction, use and management of buildings", RIBA Publications, London (1990).
[5]Olivier D, "Private Communication", (1991).

Left: Schematic showing the principles of the mechanical heat recovery ventilation system. Ducts have been positioned where they would seem part of the house rather than uncomfortable additions.

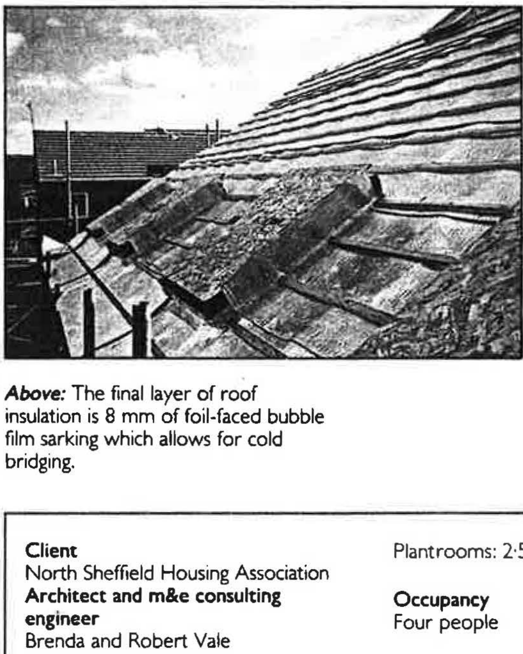


Photo: Brenda and Robert Vale

Above: The final layer of roof insulation is 8 mm of foil-faced bubble film sarking which allows for cold bridging.

Client
North Sheffield Housing Association
Architect and m&e consulting engineer
Brenda and Robert Vale
Structural engineer
E J Allott & Associates
Quantity surveyor
Gordon Hall Grayson
Main and m&e contractor
W Torry

Main suppliers
Boilers: Worcester Engineering
AHUs, ductwork, grilles and diffusers and heat exchangers: Wickes
Lights: Wotan
Luminaires: Merchant

Engineering data
Total area gross: 91 m²

Plantrooms: 2·5 m²

Occupancy
Four people

External design conditions
Winter: −5°C sat

Internal design conditions
Winter: 20°C

Loads
Heating: 1·7 kW
Installed load: 2 kW

Air volumes
0·8 ac/h

Costs
Total: £91 200