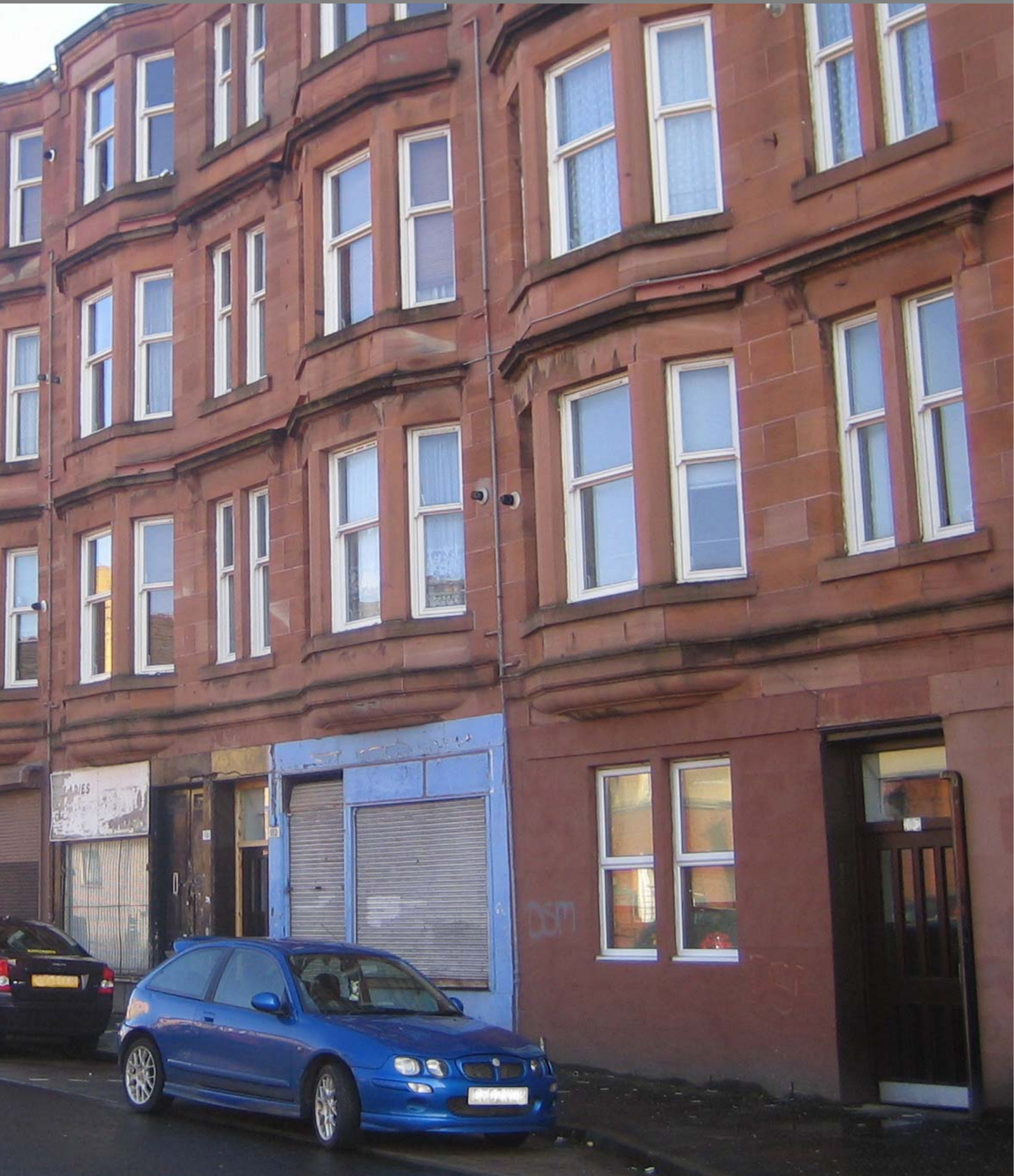
Refurbishment Case Study 4

HISTORIC SCOTLAND
ALBA AOSMHOR

Sword Street, Glasgow

Internal wall insulation to six tenement flats



This case study was published by Historic Scotland, an executive agency of the Scottish Government.

This publication is a web publication and is available for free download from the Historic Scotland website:
www.historic-scotland.gov.uk/refurbcasestudies

This publication should be quoted as:
Historic Scotland Refurbishment Case Study 4

ISBN 978 1 84917 100 7

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Internal wall insulation to six tenement flats

Moses Jenkins

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Acknowledgements

Historic Scotland would like to thank all partners participating in this case study:

REIDVALE HOUSING ASSOCIATION

GCU Glasgow Caledonian University

1. Introduction

This report is the fourth in a series of *Refurbishment Case Studies* that describe site trials carried out by Historic Scotland. As with the others produced to date, the aim of the project described here was to examine methods and materials that could be used to improve the thermal performance of traditionally constructed buildings. There was a desire, where possible, to use materials which were natural and vapour permeable to help maintain the performance of mass masonry walls. In this trial, work was carried out only to the walls, as the principal aim was to demonstrate that the thermal performance of mass masonry walls could be upgraded whilst still retaining water vapour movement through the building fabric. This case study therefore examines two measures of performance - the improvement in thermal properties and the assessment moisture levels within the walls following the installation of the insulation measures. Five different insulation materials were used in the trial in order to provide comparative data to compare relative improvements in thermal performance.

2. The site

The tenement property at which the trial took place is four storeys in height - the ground floor comprising retail accommodation and each of the upper three floors containing two flats. It is constructed of sandstone rubble masonry with brick internal partitions, and dates to around 1890 (Fig. 1). Due to structural repairs the tenement was empty at the time the trials taking place and the owner, Reidvale Housing Association, allowed Historic Scotland to install and monitor insulation in six of the flats off the common stair. All internal wall linings had been stripped out and replaced with dry lining in a previous extensive refurbishment. This meant that there were no limitations regarding the retention of original wall linings or decorative cornices, which would be the case in many similar properties.

Fig. 1. The tenement at Sword Street

3. Pre-intervention thermal performance

The external walls of all six flats were measured by Glasgow Caledonian University, prior to improvement works taking place using standard equipment (Fig. 2), and all were found to have an initial U-value of 1.1; the thermal performance of the mass masonry walls with the existing dry lining in place. This was broadly in line with the results of Historic Scotland's wider program of testing the thermal performance of mass masonry walls. The results of this, and greater detail of the methodology for obtaining U-values, can be found in Historic Scotland *Technical Paper 10*.

Fig. 2. Monitoring equipment for measuring the U-values of walls before and after the works

4. Improvements to external walls

Measure 1 – Blown polystyrene bead

The first material to be tested was bonded polystyrene bead, which was to be blown behind the existing wall lining (Fig. 3). At Sword Street this lining was plasterboard; further trials are on-going as to the application of this type of insulation behind lath and plaster walls (see *Refurbishment Case Studies 2 and 5*). The first stage in the process was to remove skirting boards and to ensure all voids at floor level were filled so that the insulation material did not disperse to other areas of the building. Before the insulation could be installed it was necessary to carry out re-lining of electrical cables as these could become brittle if they came into contact with the polystyrene bead. Holes 26 mm in diameter were cored approximately every 200 mm from the ceiling and centred between existing timber straps. The bead was then blown into the cavity between the plasterboard and the masonry. As the bead passed through the nozzle, it was coated in a water based adhesive to ensure the beads formed a cogent mass. The holes were then filled and a skim coat of plaster was applied.

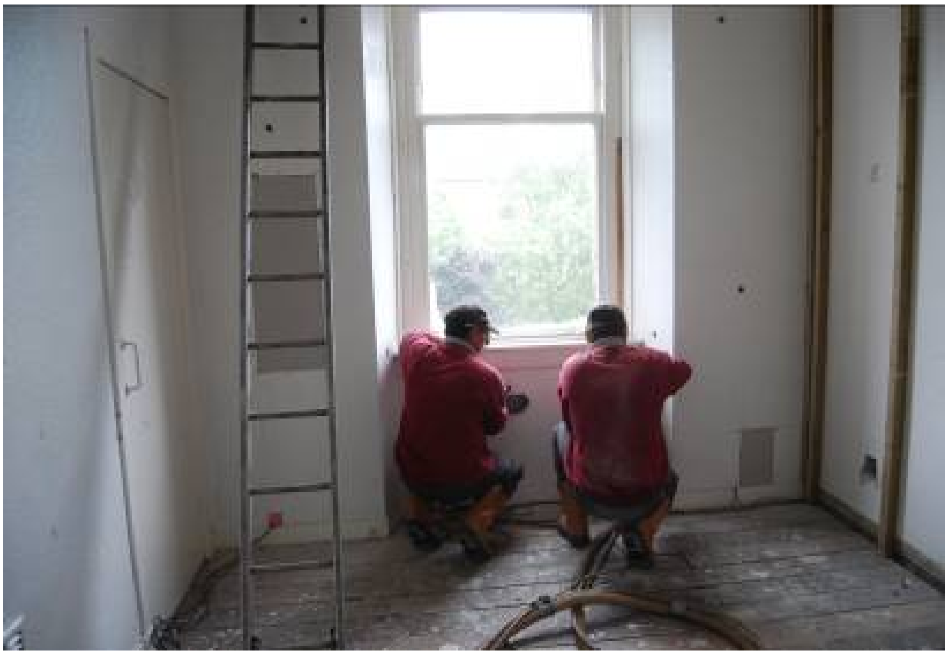

Fig. 3. Blowing bonded polystyrene bead behind existing wall lining

Measure 2 – Blown cellulose

The second measure trialled was the use of cellulose insulation applied directly to the masonry. Firstly, the existing plasterboard wall lining was stripped off and timber straps fitted to increase the depth of the void to 100 mm. Cellulose insulation was then sprayed damp between the new strapping (Fig. 4) and trimmed down to give a flush finish (Fig. 5). The wall was then re-sheeted with 12.5 mm thick plasterboard.

Fig. 4. Blown cellulose material sprayed damp directly onto masonry

Fig. 5. Cellulose fibre trimmed finished flush prior to sheeting with plasterboard

Measure 3 - Hemp fibreboard

Thirdly, insulated board made from hemp fibre was applied between timber strapping. Two layers of 50 mm board were used to obtain a thickness of 100 mm (Fig. 6).

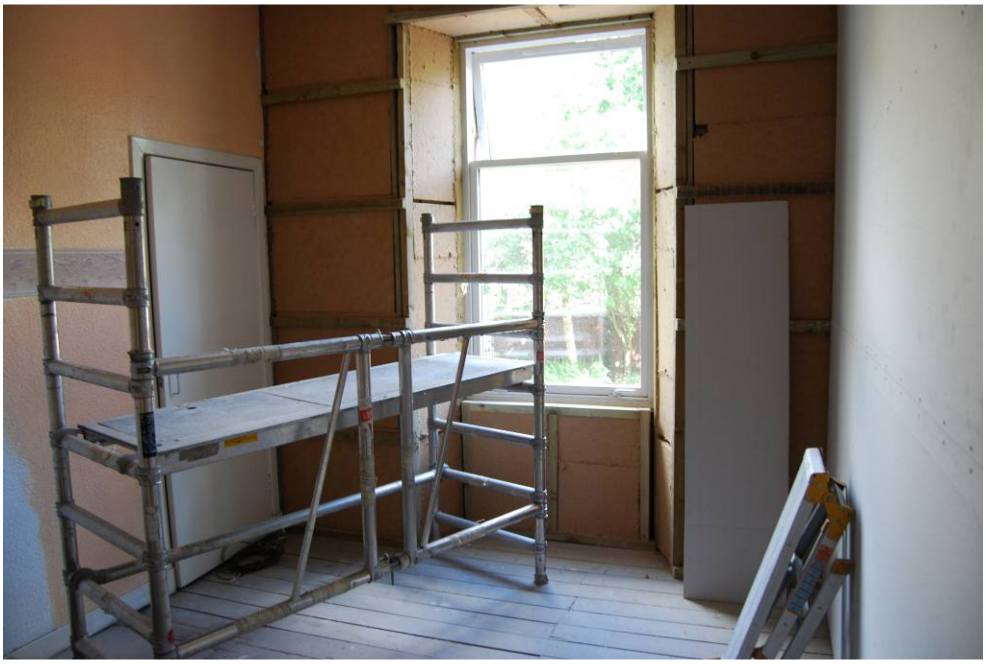

Fig. 6. Hemp board insulation applied between timber framing

Measure 4 - Wood fibreboard

The fourth material tested was wood fibreboard, again applied between timber strapping, although a thickness of only 80 mm was used. For measures three and four, the walls were re-sheeted with 12.5 mm thick plasterboard.

Measures 5 and 6 - Aerogel board

The final two options tested were 40 mm and 50 mm thick aerogel board. Aerogel is a synthetic porous material derived from a gel, in which the liquid component of the gel has been replaced with a gas, resulting in a material with very low density and thermal conductivity. For the application of this the existing plasterboard lining was stripped out and metal framing applied to the masonry. The aerogel insulating board was then secured to this (Fig. 7) and finished with a skim plaster coat.

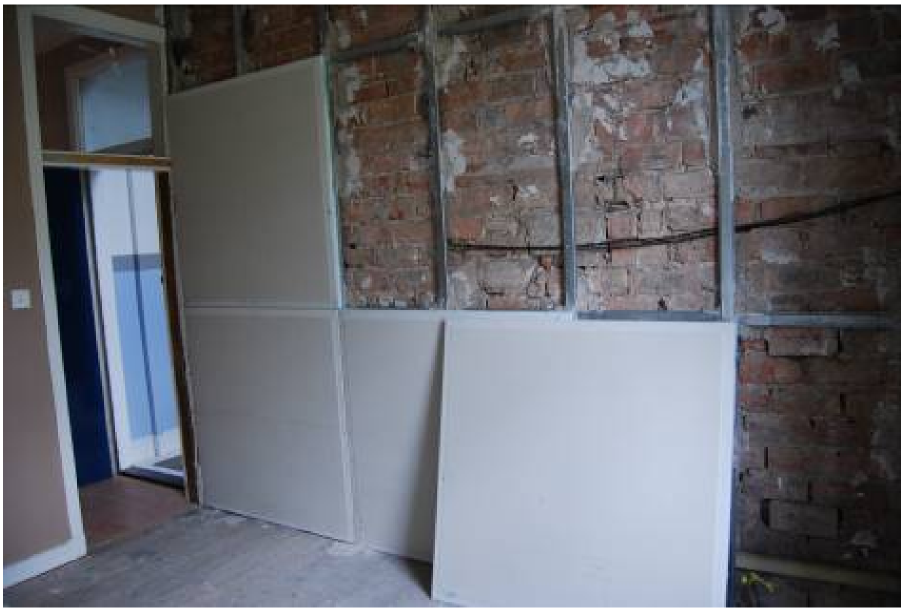

Fig. 7. Aerogel insulated board being applied to mass masonry on metal straps

5. Post-intervention thermal performance

The results of the thermal improvement made by each of the insulation materials are summarised in Table 1. These show that the thermal performance of traditionally constructed solid wall masonry can be improved substantially by using a range of different types of internal insulation. The greatest improvement was gained by the use of 80 mm thick wood fibreboard, which gave an 81% improvement in U-value. This, as well as hemp board, 50 mm aerogel board and blown cellulose all brought the U-value of the wall to below 0.3, which was, at the time of testing, new build standard. The two products that did not meet this standard came within 0.02 (injected polystyrene) and 0.07 (40 mm aerogel) of doing so. All the products can therefore be seen to make a significant improvement to the thermal performance of a traditionally constructed mass masonry wall.

Insulation	Thickness applied	U-value prior to improvement	Improved U-value
Wood fibreboard	80 mm	1.1	0.19
Hemp board	100 mm	1.1	0.22
Aerogel board	50 mm	1.1	0.23
Blown cellulose	100 mm	1.1	0.29
Injected polystyrene bead	50 mm (approx)	1.1	0.32
Aerogel board	40 mm	1.1	0.37

Table 1. The thermal improvement shown by U-values for the six internal insulation measures trialled at Sword Street

It should be noted that there are likely to be situations where it will not be possible to apply a thickness of 80 mm or 100 mm of material to a wall, for example where cornicing or skirting boards are present. A material that gives the greatest improvement for the least thickness then becomes desirable and these trials show this to be aerogel board. Reducing the thickness of any of the materials used will inevitably decrease the improvement in thermal performance and this should be taken into account when work is being planned.

A second issue to emerge during these tests is that of cost; the cheapest option was the blown bonded polystyrene bead. This was partly due to the material cost being low, but more significantly due to the ease of installation. The hemp and wood fibreboards were similar in price, with the wood fibreboard being slightly more expensive, although this may be offset by a greater improvement in U-value for a thinner material. The most expensive option was the aerogel board although it could be argued that the increased cost is offset by the considerable saving in required thickness.

6. Moisture monitoring

In addition to measuring the improvement in thermal performance, the trials at Sword Street also measured changes in moisture levels within the fabric of the masonry walls that may have resulted from the application of the insulation. This was measured by the use of probes at the junction of the inner masonry and the insulation, and at a depth of 50 mm into the thickness of the wall (Fig. 8). The results of this monitoring are summarised in Table 2. It is considered that none of the insulation measures being trialled is leading to a damaging increase in moisture over time, at either the interface of the insulation and the wall or within the fabric of the stone. Whilst the relative humidity was, in three cases (aerogel board, hemp board and wood fibreboard), higher than that in the room, only in the case of the wood fibreboard was there a considerable difference and all of these were still within acceptable limits. The humidity for the blown cellulose and bonded bead insulation was lower at both the interface and within the fabric of the wall. It is also important to note that whilst the results are averages, in no cases did the humidity rise significantly over the 18-month monitoring period. These results are significant as they go some way to proving that insulation can be safely applied directly to mass walls without using a vapour barrier. Further monitoring will continue to examine this issue over a longer period of time, and this paper will be updated in due course.

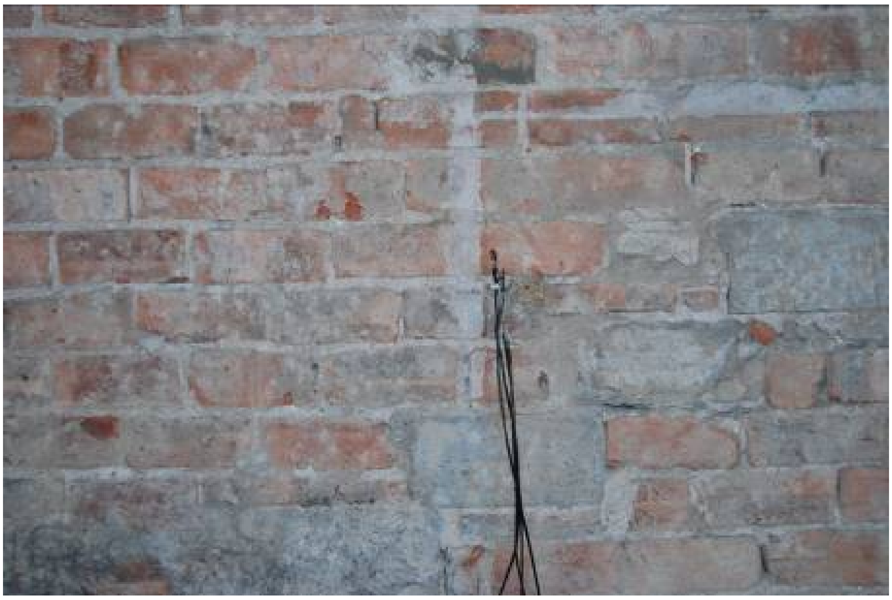

Fig. 8. Probes were set into the masonry to track any changes in humidity levels

Insulation type	Average relative humidity of room (%)	Average relative humidity at interface between wall and insulation (%)	Average relative humidity 50 mm into the wall fabric (%)
100 mm Hemp board	52.1	65.2	66.6
80 mm Wood fibreboard	20.7	61.7	58.9
40 mm Aerogel board	No Results	No Results	No Results
50 mm Blown cellulose	21.9	14.8	14.3
50 mm Aerogel board	45.9	64.4	63.3
50 mm Bonded polystyrene bead	58.3	16.4	15.8

Table 2. The average humidity levels over an 18-month monitoring period

7. Conclusion

The insulation trials described in this case study show that six different internal insulation measures could significantly improve the thermal performance of mass masonry walls. Four of these measures achieved a U-value of below 0.3. All of the measures were aimed at maintaining vapour permeability, and monitoring of moisture levels at the interface between the insulation and the masonry and at 50 mm within the masonry show that there are no significant increases in moisture due to the insulation work. Further on-site testing of internal insulation measures are on-going and the results of these, along with those from other Historic Scotland pilot studies show that the thermal performance of traditionally constructed mass masonry walls can be significantly improved using materials which are sympathetic to the existing building fabric. Historic Scotland *Technical Paper 17* considers these in more detail.

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2 Wells o' Wearie, Edinburgh
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3 Wee Causeway, Culross
Insulation to walls and roof

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Internal wall insulation to six tenement flats

5 The Pleasance, Edinburgh
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6 Kildonan, South Uist
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7 Scotstarvit Tower Cottage, Cupar
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