INFORM

INFORMATION FOR HISTORIC BUILDING OWNERS

Improving Energy Efficiency in Traditional Buildings

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Introduction

As pressure grows to reduce CO_2 emissions, so does the need for owners and managers of traditionally built structures to improve energy efficiency and reduce fuel consumption. Whilst it has now been proven these buildings perform better thermally than is often assumed, there is still much that can be done to improve their performance. This INFORM guide provides information on some basic ways to improve the thermal performance of a traditional building and its individual elements which are sympathetic to its character and construction type. In some cases listed building consent may be required, but this consent process should not be seen as a barrier to appropriate improvement. However, not all measures will be appropriate in all circumstances and owners will have to make site specific assessments with the assistance of a suitable building professional.

How a traditional building works

It is important when considering any work to a traditionally constructed building to understand how that building was designed to work. In simple terms many such buildings were designed with passive ventilation which ensured air flow around building elements helping disperse water vapour and keeping the fabric free from excessive moisture and subsequent decay. The materials used also allowed the free movement of water vapour within the structure (Fig. 1). It is important to ensure that when taking steps to improve the thermal performance of a traditional structure, these dynamics are not compromised to the detriment of the building. That is not to imply that we should live with draughts, but that sufficient air movement and exchange is maintained for the good of the fabric and the health of the occupants. In addition, the careful use of vapour open finishes will assist in the management of humidity in the home, and the improvement in indoor air quality due to the reduced prevalence of high relative humidity and consequent water vapour condensation on some surfaces.

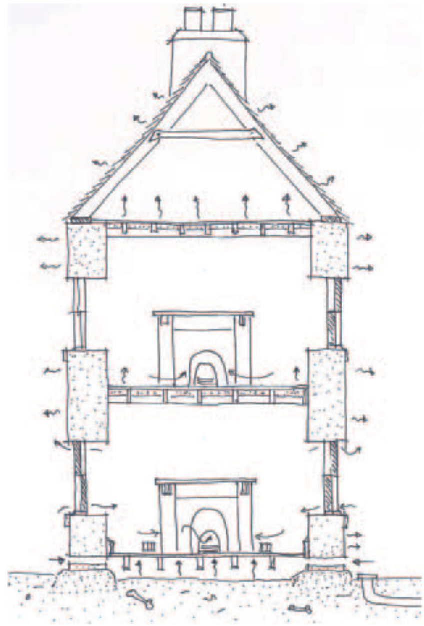

Fig. 1 *Section through a traditionally constructed building showing airflow and vapour movement.*

Heating regimes and equipment

Before considering any upgrade to building fabric, it is important to first ensure that space heating equipment such as boilers and radiators are being used efficiently. Studies have shown that the effective use of such equipment can have a larger impact on reducing emissions and fuel consumption than fabric interventions. Where central heating is used this should be fitted with proper controls and these should be well understood by the building owner or occupier.

Roofs and attics

Approximately 25% of heat is lost through a typical roof, so installing suitable levels of loft insulation is a good starting point in improving the thermal performance of any building. At least 270mm of insulation is required to be fully effective. There are many types available, from natural materials such as hemp fibre boards or sheep's wool, to recycled products made from newspaper, and others made from glass and modern materials. In most circumstances natural materials are preferable in traditional buildings, as they are better able to buffer moisture and prevent condensation. Insulation can be placed between the ceiling joists in the conventional way, giving what is called a "cold roof", or fitted between the rafters, giving a"warm roof". Wood fibre board has proved effective in this context (Fig. 2). It is important when installing any loft insulation to ensure coombs are effectively insulated whilst at the same time maintaining ventilation throughout the roof space. Current guidance is that there should be a 40mm gap between the top of the insulation and the underside of sarking boards. In some properties bats may be using the roof space as a roost; should this be the case advice should be sought from Scottish Natural Heritage or the Bat Conservation Trust.

Floors

Where there is a timber floor at ground level, often called a suspended timber floor, there may be sufficient crawl space to allow insulation to be installed on the underside. However in most circumstances there is not enough space and insulation needs to be installed from above. If it proves necessary to lift the boards to install the insulation this should be done with care to avoid damage to the original fabric, and may be deemed not worth the risk. If floorboards are lifted with care most can be re-laid, with some new boards typically being needed to make good any damage. An experienced joiner can sometimes remove every 5th or 6th board, reducing disruption and damage. However the cost of this work should be weighed with the benefit from insulation being installed. As with loft insulation, a material which

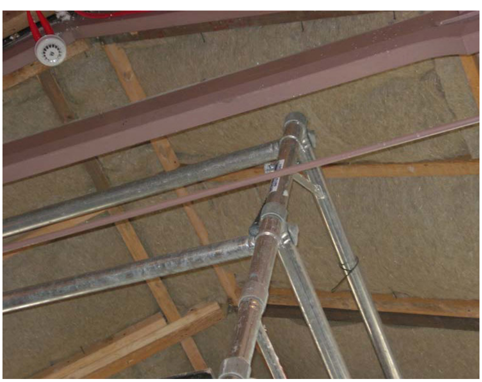

Fig. 2 *Wood fibre board fastened between rafters.*

Fig. 3 *Stone flags back in place after the laying of an insulated lime concrete floor.*

allows some degree of moisture movement should be used, whether it's installed from above or below. Laying non-permeable insulating board on top of a timber floor will inhibit water vapour movement, and may give rise to timber decay. Solid flagstone floors should generally be left in situ as lifting them may cause damage. However, where a flagstone floor requires to be lifted for other reasons it may be worth considering laying an insulated lime concrete floor under the flags (Fig. 3). There are considerable benefits in insulating new concrete flooring with a proprietary insulation, where original floor finishes have been lost. In tests carried out by Historic Scotland, the U-value of such a concrete floor was improved by a factor of 6.

External doors

Whilst the frame of a traditional timber door generally performs well thermally, improvement can often be made to the panels which are typically made of thinner wood. This can be done by adding a layer of appropriate thin insulation material on the inside of the door panel, thus maintaining the character of the door from the outside (Fig. 4). Due to its higher performance than conventional products, such materials can be expensive, but in small areas it allows the sensitive upgrade of an otherwise sound door. In all cases the finished insulation should be kept flush with the door framework; new beads may be required to finish the edge. Draught or weather stripping around the edge of the door and the letter box can also help. There is little need to insulate internal doors, unless there are significant heat differences between rooms.

Fig. 4 *A 19th century timber door with insulation installed in the panels.*

Windows

Whilst a single pane of glass has a fairly poor thermal performance with a U-value for most traditional glass of around 5.2, there is a range of sensitive upgrade options which can considerably improve this. Draft stripping of the sashes can reduce air leakage by 80%, as well as allowing the full use of the window in terms of opening and closing, although it will not improve the U-value. Many companies provide this service, which combines the upgrading work with a general overhaul of the window and the sash cords. There are many improvements which can be made to the thermal performance of a window without intervening in its fabric. These are summarised in Table 1 which gives the results of Historic Scotland tests on a number of improvement measures. These tests showed that secondary glazing is the most effective option, as it reduced heat loss through the window by 63%. Timber shutters are the most effective option of the traditional methods, reducing heat loss by 51% (Fig. 5) with the level of improvement gained by the other options shown below. The greatest reductions in heat loss came from a combination of measures. Using secondary glazing, or combinations of blinds and shutters, reduced the U-value of the window to around or below 1.6, which is approaching the maximum U-value allowed by Scottish Building Standards for timber or uPVC windows in new dwellings. Whilst many of these options do shut out natural light, the

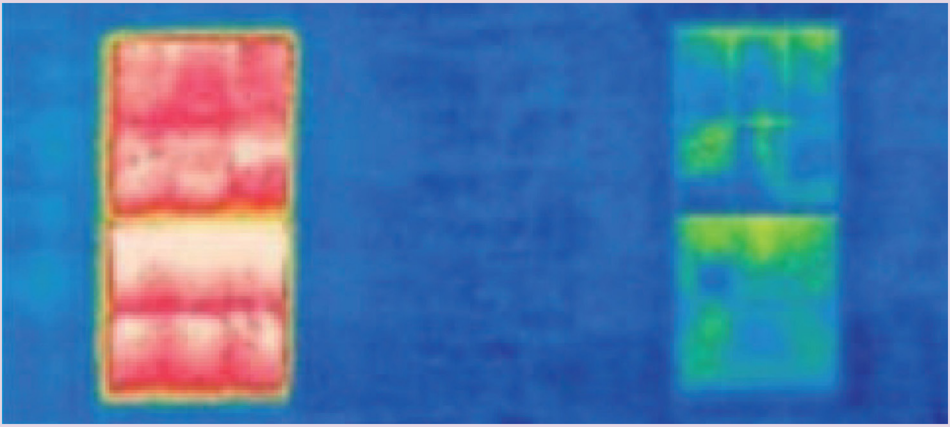

Fig. 5 *Thermal image showing the reduction in heat loss with shutter closed (right) and shutter open (left).*

period of lowest temperature (and therefore greatest heat loss), is at night when lack of light should not be an issue.

For more significant improvements, interventions to windows will require alterations to glazing. This includes a range of double glazed units which can be retrofitted into existing sash and case windows to greatly improve energy efficiency without adversely altering the character of the window. Before carrying out any work, the historic significance of the existing glazing must be considered. Improved glass comes in the form of slim profile double glazing, or more advanced products involving vacuum panes (Fig. 6). Whilst sash and case windows are extremely durable and when well maintained will last many years, if extensive repair or replacement

Improvement method	**Reduction in heat loss**	**U-value W/m²K**
Unimproved single glazing		5.4
Fitting and shutting heavy curtains	14%	3.2
Closing shutters	51%	2.2
Modified shutters, with insulation inserted into panels	60%	1.6
Modern roller blind	22%	3.0
Modern roller blind with low emissivity plastic film fixed to the window facing side of the blind	45%	2.2
Victorian blind	28%	3.2
A “thermal” duette honeycomb blind	36%	2.4
Victorian blind and shutters	58%	1.8
Victorian blind, shutters and curtains	62%	1.6
Secondary glazing system	63%	1.7
Secondary glazing and curtains	66%	1.3
Secondary glazing and insulated shutters	77%	1.0
Secondary glazing and shutters	75%	1.1
Double glazed pane fitted in existing sash	79%	1.3

Table 1 *Results of U-value testing for improvement measures to sash and case windows.*

Fig. 6 *Vacuum pane glazing inserted into original window.*

Fig. 7 *Where inappropriate cement render has been applied to a traditional building its replacement with an insulated lime based material may be appropriate.*

of windows is necessary, modern glazing options may be considered. Not all options are appropriate in all cases but there will always be a combination of measures suitable to improve the thermal performance of windows in traditional buildings.

Improvements to walls

External wall insulation

External wall insulation will not be appropriate in all circumstances. Where there is ashlar work of a high quality or a masonry sensitive façade, its application would not be appropriate due to the negative visual impact. However, in a situation where a building has been rendered, the application of an insulated replacement can be considered (Fig. 7). This is particularly the case where the render is an inappropriate cement based material, the removal of which would help both the health of the building and its thermal performance. When considering external insulation it is important to use a material which is appropriate. This is likely to take the form of an insulated lime render containing a material such as hemp fibre or expanded clay aggregate. Boards and spray applied material which does not allow a degree of moisture movement through the structure should not be used as the long term effects are still to be assessed, and invariably require the formation of complex junctions between the new wall plane and existing details such as eaves, rhones and downpipes.

Internal wall insulation

Generally in Scotland a dry masonry wall of around 600mm in thickness will provide a reasonable thermal barrier, although current thermal assessments tend to consider them as thermally poor. Where lath and plaster remains in situ its removal is not recommended. Internal insulation which requires the removal of existing wall linings is only appropriate where there are no historic and original materials extant. There are options which may be tried in terms of putting material such as polystyrene bead behind the existing lath and plaster. Polystyrene bead can be blown behind the existing wall finish after some re-wiring work has taken place for electrical safety reasons (Fig. 8). Another option which is being developed is using a thin (10mm) aerogel insulation applied as a wall covering. Historic Scotland's tests have shown, however, that lath and plaster with a void behind provides a degree of insulation in itself and it may be better not to intervene where such lath and plaster is still in place.

Where a more significant upgrade is required there are a range of insulation types which can be applied to walls internally. Historic Scotland tested some of these, the results of which are shown in Table 2. These and other products can be applied in a variety of different ways. The board type insulation is fitted between existing or new timber strapping and can be finished with a skim coat of plaster. Materials such as the blown cellulose is sprayed on damp and finished with a board being placed over the material (Fig. 9). All the materials tested gave significant improvement to the thermal performance of the building. A more recent range of insulating products, for instance insulated lime plaster, are now available and are especially suited to the refurbishment of vernacular and smaller buildings, where the softer lines and edges can give a pleasing effect (Fig. 10). Whatever materials are selected, it is important to ensure that they have a good degree of vapour permeability and do not incorporate or create a vapour barrier which could lead to a build-up of moisture in a wall.

Fig. 8 *Insertion of bonded polystyrene bead insulation behind plasterboard.*

Fig. 9 *Blown cellulose material applied to mass masonry wall between timber strapping.*

Fig. 10 *Insulated lime plaster on a traditional mass wall.*

Insulation type	**Unimproved U-value W/m²K**	**Improved U-value W/m²K**
100mm hemp board between timber straps	1.1	0.21
90mm wood fibre fitted between timber straps	1.1	0.19
30mm insulated board onto timber straps	1.1	0.36
50mm cellulose fibre damp sprayed between timber straps	1.1	0.28
40mm insulated board onto timber straps	1.1	0.22
50mm bonded polystyrene bead	1.1	0.31

Table 2 *Improvements in U-value given by various internal insulation options applied to a solid walled tenement.*

Conclusion

Through a selection of appropriate measures that are technically and aesthetically compatible with traditional fabric, the thermal performance of older structures, both listed and unlisted, can be improved significantly; giving better thermal comfort and indoor air quality. Such measures need to be carefully planned and delivered to ensure the full benefits are realised and a durable, long lasting refurbishment is achieved.

Further reading and contacts

Historic Scotland Conservation (technical advice)
T: 0131 668 8668
E: hs.conservationgroup@scotland.gsi.gov.uk
W: www.historic-scotland.gov.uk/conservation

Scottish Natural Heritage
Guidance on work that might affect roosting bats.
T: 01463 725 000
W: www.snh.org.uk

The Sustainable Traditional Building Alliance (STBA)
Guide to Responsible Retrofit.
T: 0207 704 3501
E: Info@stbauk.org
W: www.responsible-retrofit.org

English Heritage (climate change advice)
W: www.climatechangeandyourhome.org.uk

Energy Savings Trust
T: 0845 120 7799
E: bestpractice@est.org.uk
W: www.est.org.uk/housingbuildings

Short Guide 1: *Fabric Improvements for Energy Efficiency in Traditional Buildings.* Historic Scotland. 2013 (2nd edition)

Energy Efficient Refurbishment of Existing Housing (CE83). Energy Savings Trust, November 2007

A number of publications are downloadable from Historic Scotland's technical conservation website (address above). Publications available include Technical Papers and Refurbishment Case Studies detailing Historic Scotland research are available as well as our INFORM Guide and Short Guide series. For more information on publications please email us on hs.cgpublications@scotland.gsi.gov.uk

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