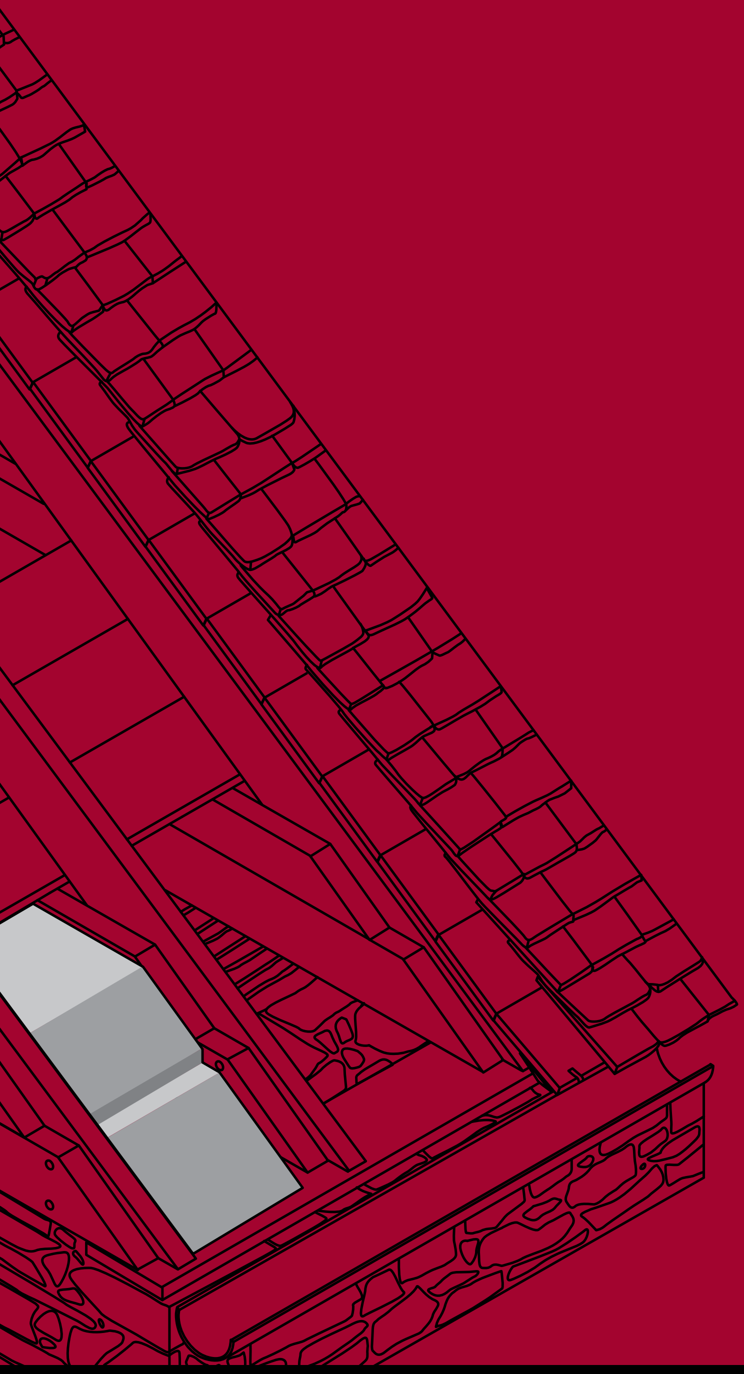
Short Guide

# Fabric Improvements for Energy Efficiency in Traditional Buildings



Historic Scotland
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# Contents

# 1. Introduction

The Climate Change (Scotland) Act 2009 commits Scotland to some of the most ambitious carbon reduction targets in the world, including the reduction of greenhouse gas emissions by 42% by 2020; and 80% by 2050 from 1990 levels (Scottish Government 2009). With around 40% of Scotland's total carbon emissions coming from domestic energy consumption and almost 20% of all buildings being traditionally constructed, improving energy efficiency in these buildings is key to meeting the national carbon reduction commitments. As a government agency, Historic Scotland has been mandated to take the lead in research and guidance to improve energy efficiency in traditional and historic buildings, as laid out in *The Energy Efficiency Action Plan (Scottish Government 2010)*, and further articulated in the *Historic Scotland Climate Change Action Plan (Historic Scotland 2012)*.

Traditional buildings are generally considered to be those built before 1919 using load-bearing mass masonry walls, with pitched roofs covered in slate or another natural roofing material. Windows are generally single glazed with timber frames, often in the sliding sash and case pattern, and the buildings have internal timber and lime plaster finishes and passive ventilation systems. The term 'traditional buildings' covers a broad range of buildings, not just those referred to as 'listed', 'historic' or 'heritage'. Scotland has around 400,000 pre-1919 buildings, comprising approximately 20% of the total building stock, approximately 47,000 of which are listed. Such structures include cottages, villas, public buildings and commercial buildings as well as tenements, which are prevalent in the Central Belt of Scotland (Fig 1).

This guide presents a series of practical solutions to improving energy efficiency in traditional and historic buildings, through a range of specific fabric improvement measures to different elements of a building (specifically roofs and lofts, floors, windows and doors, walls and chimneys). Crucially, the methods outlined in this report allow the building to continue to function in terms of maintaining ventilation and moisture permeability, whilst retaining historic character and minimising the visual impact of the changes. The examples given are based on a series of trials and pilot projects undertaken or managed by Historic Scotland in which energy saving measures were trialled at a variety of traditional properties throughout Scotland, including detached rural cottages, tenement flats, townhouses and public buildings dating from the 18th, 19th and early 20th centuries. The results of these projects are published as a series of *Refurbishment Case Studies* available from the Historic Scotland website, where the specific measures are described in more detail. Attention is also drawn to the *Historic Scotland Technical Papers* (also available on our website) which provide detailed information on relevant technical issues such as U-value measurements in traditional buildings, thermal performance of traditional windows, energy modelling and thermal comfort.

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Fig 1 Traditionally constructed houses in South West Scotland.

This guide does not aim to provide detailed specifications for work to be undertaken; rather it seeks to give indicative details of possible approaches and potential results. Not all the measures described will be appropriate or possible in every case and each situation should be assessed on its own merit with the most relevant measures taken based on the specific circumstances, especially the historic significance of the building or fabric element. Such considerations should always be kept in mind and balanced against possibly more effective savings from demand side reductions. The research to date suggests that there is likely to be a technique suitable to improve the thermal performance of most traditional buildings without adversely affecting their fabric and character.

Whilst this guidance focuses on interventions to the fabric of buildings and the upgrades described are broadly in a hierarchy that reflects ease and cost of the measures, such work should only begin after other methods of reducing energy demand have been undertaken. Improvements to services such as heating systems and lighting, and occupier behaviour, will have a significant impact on reducing energy use in a building. Furthermore, the field of energy efficiency improvements is a rapidly evolving one, and new solutions and approaches are likely to emerge over the next few years. Many of the Historic Scotland pilot projects described are subject to on-going monitoring, and further results and updates will be published in new versions of this guide and updates to the *Refurbishment Case Studies*.

The measures described in this guide are likely to be relevant to most traditional buildings and some historic ones; however where a building is listed or in a conservation area there may be restrictions on work and Listed Building Consent or Conservation Area consent may be required. Similarly some procedures may require a building warrant. Further information can be found in *Building Standards Division Technical Handbooks* or by contacting local authority Building Standards Departments. In all cases it is advisable to contact the local authority Planning Department prior to starting any work to establish whether planning permission, listed building consent or a building warrant is required.

Throughout this publication the effectiveness of specific insulation measures is indicated using U-values. A U-value is the amount of heat lost (in Watts) per square metre of material at a temperature difference of one degree (measured in Kelvin). In building fabric work, the lower the U-value, the better the insulation or element is performing thermally. All the U-values presented here are actual measurements (expressed as $W/m^2K$) from the Historic Scotland energy efficiency pilot projects (*Refurbishment Case Studies*). More details on U-values in traditional buildings can be found in *Historic Scotland Technical Papers 1, 2 and 10: Thermal Performance of Traditional Windows, In situ U-value Measurements in Traditional Buildings and U-values and Traditional Buildings*.

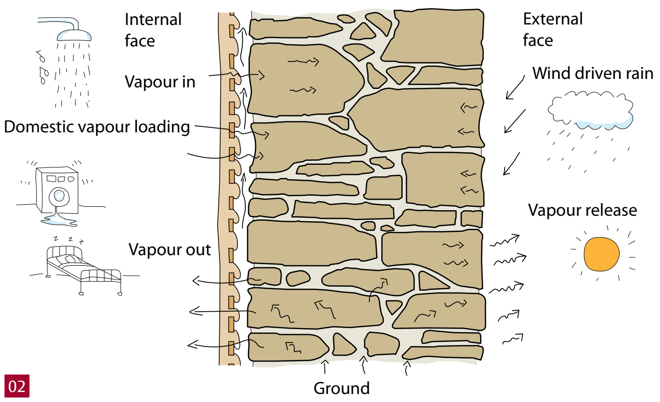
This document is published jointly with the Energy Saving Trust, who give impartial advice on how to reduce domestic energy and carbon dioxide emissions in the domestic energy sector, and they should be the first point of contact when seeking advice on further upgrade works. They also provide advice on sustainable transport and renewable technology, as well as access to funding schemes. This advice is delivered through the Energy Saving Scotland advice centre network, managed by the Energy Saving Trust and funded by the Scottish Government and Transport Scotland.

# 2. Principles

Research by Historic Scotland supports the view that there are two key principles for improving thermal performance in traditional buildings, and these underpin the advice given in this guide: firstly that the materials used should be appropriate for the building, and in most cases water vapour permeable, and secondly that adequate ventilation should be maintained to ensure the health of the building and its occupants.

*Breathable construction.* Traditional buildings are often referred to as being of 'breathable construction' that acknowledges the fact that the materials used for their construction have the ability to absorb and release moisture. Such materials are often referred to as 'hygroscopic'. This property is of benefit when seeking to buffer the peaks of humidity created through the daily tasks of occupation (Fig 2). Exactly how much water vapour is moved through component materials and at what rate will depend on the type of stone (igneous or sedimentary rock for example) which the wall is made from, the voids in the wall and the external condition of the masonry. In retrofit work, using materials and construction methods that are appropriate for traditional buildings will ensure that energy efficiency improvements are technically compatible with the building fabric and will therefore reduce the risk of damage from inappropriate interventions. Furthermore such compatibility will ensure that the upgrades are durable and long lasting.

*Ventilation.* Traditional buildings were constructed in a way that allows modest air movement through vents, windows, doors and chimneys, circulation through rooms, stairwells, and through gaps under floors and behind wall surfaces (Fig 3). This natural ventilation is important for managing moisture accumulation and clearing humid or stale air along with other vapours produced in buildings. However, when air movement becomes excessive it reduces internal temperatures and has a negative effect on thermal comfort. The difficulty is finding a balance, because if ventilation is restricted, air carrying water vapour cannot properly escape, leading to increased humidity, condensation build-up and undesirable consequences such as mould growth.

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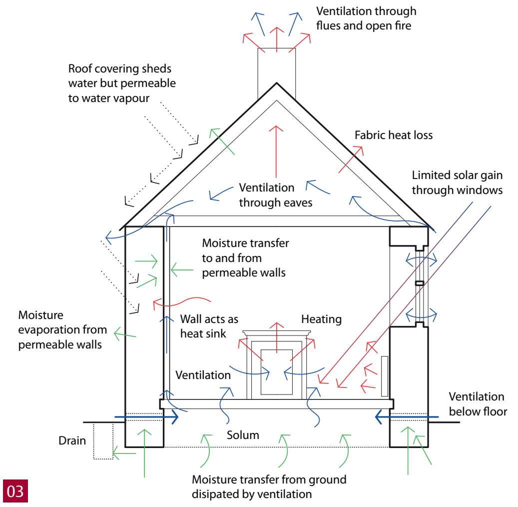


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**Fig 2** A simplified version of water vapour movement in a mass masonary wall.

**Fig 3** Air movement in a traditional building.

Consideration of moisture movement and ventilation is of fundamental importance when dealing with many older buildings. Provided these factors are taken into account, it is entirely possible to successfully increase thermal performance and reduce energy use in a traditional building without damaging either its character or the building fabric. In seeking to better manage air tightness in older buildings, a recent Historic Scotland pilot project achieved an air leakage reduction from 18 to 8 air changes per hour, using the measures described in this guide (*Refurbishment Case Study 7*). This is a degree of air tightness, which exceeds modern requirements and challenges the assumption that all old buildings have to be draughty.

In projects where a building warrant is required, and compliance with Section 6 of the Scottish Building Regulations is necessary achieving the standards set out in the functional standards may not be possible. In this case a client or project team may wish to appoint an approved certifier of design to develop a solution that achieves compliance. Several schemes are run in Scotland which suit the circumstances of traditional and historic buildings.

*Maintenance.* It should be said that proper and regular maintenance is a prerequisite to undertaking energy efficiency improvements in a traditional building. If a building is not watertight there is little point in making energy efficiency upgrades, and if dampness or excess moisture is already present such upgrades may cause further moisture and damage. Furthermore, heat loss through a damp masonry wall is higher than from a corresponding dry wall. Details of appropriate maintenance measures in traditional buildings are given in a number of Historic Scotland publications, including the *Historic Scotland Short Guide Maintaining Your Home* and other publications available on the Historic Scotland technical conservation website.

# 3. Fabric upgrades

## 3.1 Roofs and lofts

### Introduction

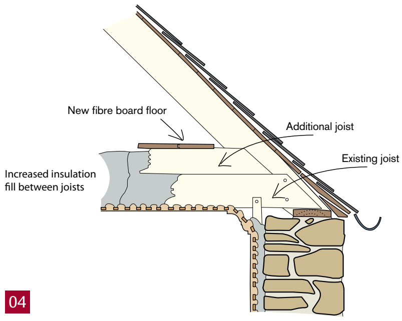
Typically around 25% of heat is lost through the roof of a building; therefore loft insulation is a common and effective means of reducing heat loss. Broadly there are two approaches to roof insulation: insulating at ceiling level, which creates a cold roof space, or between the rafters creating a relatively warm roof space. These approaches, along with how to insulate less common roof types, are described in detail in this chapter.

### Loft insulation

*Standard loft insulation.* When insulating a loft it is often easier to install insulation on the horizontal upper side of the ceiling in a loft, rather than between the rafters, and this is generally the approach taken by most insulation installers; this gives what is termed a 'cold roof'. In the Historic Scotland trials a vapour permeable and hygroscopic material was used to ensure effective humidity buffering and moisture management. Suitable materials include rolled material such as sheep's wool or hemp fibre 'wool', board-based materials such as hemp and wood fibreboard, and loose-fill materials such as cellulose. Generally it is easier to use material supplied in flexible rolls, which may also result in a tighter finish. Irrespective of the material used, care must be taken to avoid filling the eaves or coom where ventilation should be maintained.

Although every installation will yield different results, Historic Scotland trials have shown strong improvements in thermal performance through loft insulation, as measured by U-values. In one case the use of sheep's wool insulation improved the U-value from 1.4 to 0.2 (see *Refurbishment Case Study 2*), and in another example hemp fibre wool resulted in an improvement of 1.5 to 0.2 (*Refurbishment Case Study 3*).

Whatever material is chosen it is recommended at least 270 mm of insulation be installed to be fully effective. If the attic space is to be used, and a floor is required, then this may oblige the deepening of joists through fixing additional timbers (Fig 4). If access is not required then the additional material can be laid across the joists. If insulation is already in place with a gap of more than 50 mm to the top of the joists, top-up material can be laid between the joists or, if the space is less, across the joists. A gap in insulation or a colder spot between insulated areas is known as thermal bridge; snugly fitting insulation or laying insulation across an existing layer helps to minimise this problem. The access hatch to a loft space should also be insulated and draught proofed to prevent warm moist air entering the roof space.

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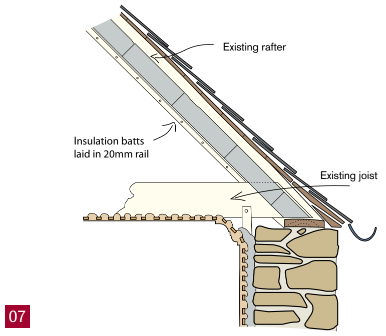


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**Fig 4** Technique for standard loft insulation with a new floor.

**Fig 5** Sheep's wool insulation laid between rafters at Edinburgh Castle. Note the accommodation of wiring above the insulation.

**Fig 6** Low profile roof vents on a slate roof following an upgrade to the roof space.

**Fig 7** Technique for insulating roof slopes.

**Fig 8** Wood fibreboard insulation fastened to rafters.

Consideration should also be given to electrical wiring in the roof space. The safest and neatest approach is to route electrical cables above the insulation material to minimise any risk of overheating (Fig 5), this will also allow access for future maintenance or alterations. In all cases, it is advised to consult a qualified electrician.

To ensure ventilation at the eaves, a 50mm gap should be left between the end of the insulation and the start of the slope of the roof over the wall head. If additional ventilation is required it should have minimal visual impact and could be achieved through vents at the eaves or on the ridge. Vents on the main roof pitch are also possible, with various types available to minimise visual impact (Fig 6).

### Insulating roof slopes

*Rafter insulation.* Roof spaces may be insulated by improving the performance of the roof structure itself. Insulation at rafter level results in a warm roof space. Where it is not possible to insulate between the joists in a loft, if it is occupied for example, it may be necessary to insulate between the rafters in a roof (Fig 7). This might also be useful if warmer attic storage space is required. If there are no linings in the roof space the technique is simple, and insulation may be cut to the width of the rafters and held in place with timber battens fastened to the cheeks of the rafters.

In order to best manage water vapour movement a vapour permeable material should be used for insulation. For ease of working, a board base material or semi-flexible batt such as sheep's wool/hemp fibreboard or a wood and wool mix might be most suitable. Any material used should fit snugly between the rafters to avoid gaps (Fig 8) and is best cut in a workshop or in open air.

In Scotland, most rafters are of sufficient depth (210 mm or 8") to give room for adequate insulation. However, if the rafters are not deep enough for the desired thickness of insulation they may be deepened by attaching timber straps to the bottom edge. If some form of lining is required then the timber batten holding the insulation may be omitted and the insulation held in by the plasterboard or other material. Where there are original linings in the attic space, follow the guidance for coom ceilings in the section below.

It is also important to ensure a degree of air movement underneath the sarking boards. A gap of 50 mm should be left between the underside of the sarking and the topside of the insulation for air circulation. Traditionally, roofs often incorporated ventilation into their construction by the inclusion of a 'penny gap' between each sarking board. This allowed air to circulate throughout the roof structure ensuring dispersal of any water blown under the slates in extreme conditions. The use of bitumen based 'under slate felt' in the post war period has contributed to less draughty attics, but ones where additional ventilation is invariably required if insulation work is carried out. Modern roofing membranes give a vapour control layer that allows passage of vapour while minimising bulk air leakage. If such materials are properly specified, roof vents are not required.

### Coom ceilings and dormer windows

Coom ceilings are a feature of many Scottish properties where the ceiling is partially or sometimes fully part of the pitched roof. Whilst not as easy as insulating a more accessible loft, there are likely to be considerable benefits in making the effort to properly insulate coom ceilings and dormers, particularly as these are often found in bedrooms.

Access to the space at the apex of the roof is required, and this is often in the form of a small trapdoor; if there is no such access it will have to be formed. The separation of the rafters should be measured and sections of insulation material cut to that width. These short sections are taken into the space and slid down into the void between coom lining and the sarking board (Fig 9 and Fig 10). As with rafter insulation, a 50 mm air gap should be left between the underside of the sarking and the top of the insulation material.

Another technique is to blow material into the void in a similar way to that discussed in section 3.5 (Fig 11). This will fill the entire void and leave no air gap, therefore an open celled material such as bonded polystyrene bead, which allows an element of water vapour and air movement, should be used. If this is done additional roof vents at eves level and above the rooms will be required.

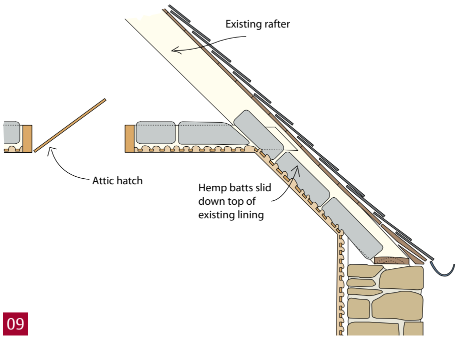
A feature commonly associated with coom ceilings is dormer windows. By their exposed nature these are a considerable source of heat loss in a roof bedroom or attic space. The cheeks (sides) of the dormer will typically require a thin insulation board to be applied, as space is limited. One option would be to use an aerogel blanket insulation, which is available in either 5mm or 10mm thicknesses. The small area of the dormer ceiling should be insulated in the normal way and is often accessible from the roof space above.

Although every case will be different and will give different results, in one Historic Scotland trial the U-value of a dormer cheek was improved from 1.7 to 1.2 by using aerogel insulation (see *Refurbishment Case Study* 6). In the same trial improvements to the glazing arrangements of the dormers were also made (see section 3.3 of this guide).

**Fig 9** Technique for insulating coom ceilings.

**Fig 10** Wood fibre insulation behind the timber lining of a coom ceiling.

**Fig 11** Blowing in bonded bead insulation to a coom.

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## Flat roofs

Insulating a flat roof presents a number of technical challenges and is harder to successfully achieve than the insulation of a loft. The methods and materials used should be carefully considered prior to any work taking place.

Flat roofs generally have some degree of slope (usually around a 1 in 60 incline), which is a standard detail to prevent ponding of water. Traditionally flat roofs are covered in metal, most commonly lead (although zinc and copper are also used), with bituminous coverings becoming common on flat roofs from the mid 19th century onwards. When insulating flat roofs, in particular those covered in a metal, it is important to reduce the risk of condensation by maintaining clear ventilation through provision of suitable vents to the outside; otherwise there will be condensation on the underside of the roof covering and consequent corrosion of the metal and decay in the roof timbers.

When insulating flat roofs the insulation is usually placed between the joists holding the sarking (or 'decking' as it is often termed) in place (Fig 12). This might require removal of all, or part of, the ceiling to allow the fitting of the insulation between joists. A rigid, vapour permeable insulation material can then be installed between the joists and close in with new linings, either reinstating lath and plaster or using a modern alternative.  The underside of a flat roof should be ventilated and a consistent, unobstructed air path of at least 50mm in depth should be provided. This technique entails considerable disruption and loss of original material in the ceiling and should be considered carefully. Where ceiling heights allow, it may be possible to apply insulation directly to the existing ceiling, finished with a new lime plaster ceiling over the insulation.

An alternative method of installing the insulation between joists is to remove the roof covering to allow access from above. This is only likely to be practical when the roof covering is to be renewed.


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**Fig 12** A typical underside of a flat roof.

## 3.2 Floors

### Introduction

A cold floor absorbs heat and can introduce cold air from below floorboards, significantly affecting thermal comfort. The thermal performance of both timber and concrete floors can be significantly improved as described below, although in the case of solid floors this can also involve significant disruption.

### Insulating timber floors

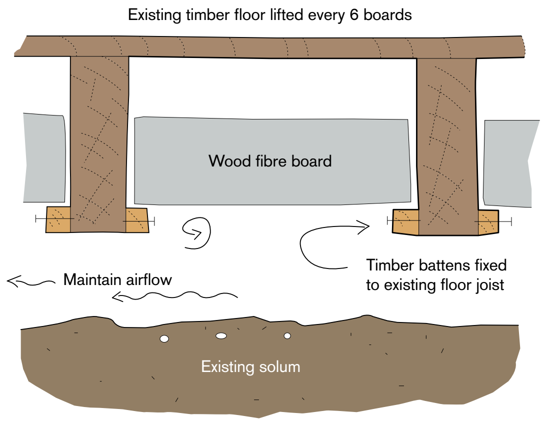
Suspended floors typically lie 300 to 500 mm above the solum, carried by timber joists, in a clear span or sometimes supported by sleeper walls. Effective insulation is best installed below a timber floor and, as with loft insulation, a vapour permeable material should be used to avoid accumulations of moisture, which may lead to rot or other forms of damage. Hemp batts and wood fibreboard have been shown in Historic Scotland trials to be appropriate for the insulation of timber floors.

The approach with floors is largely dictated by access and quality and value of the floor. If the floor is accessible from below with a reasonable crawl space, a stiff or semi rigid insulation material can be fixed directly between the joists with timber battens, or a softer more flexible material is held by a net fixed between the joists. This will allow the floor timbers to remain undisturbed. However, even if there is a crawl space, consideration should be given to the working conditions and the suitability of activity in restricted spaces.

Where such access is not possible it will be necessary to lift the floorboards to install the insulation. At this stage it may be decided that the disruption and potential damage means the work cannot be done. This might be the case where there is timber parquet or some other complex layout. If the floor can be lifted, rigid wood fibreboard can then be laid on timber runners fastened to the sides of floor joists. Careful cutting of the board is required to ensure a tight fit (Fig 13) and this is sometimes best done off site. The lifted boards are then re-fixed (Fig 14). One Historic Scotland trial using an 80 mm wood fibreboard (shown in Fig 13 and Fig 14) resulted in an improved U-value of the floor from 2.4 to 0.7 (see *Refurbishment Case Study 2*). During such work it is prudent to check the integrity of the masonry and mortar around the joist ends as they enter the wall. Any voids or areas of missing mortar should be pointed up to ensure structural integrity and reasonable air tightness.

**Fig 13** Technique for placing insulation board between floor joists.

**Fig 14** Floor boards being re-fixed following insulation.



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In one of the Historic Scotland trials it was found that careful lifting of every sixth floorboard allowed sufficient access to fasten battens to the sides of the floor joists and the fitting of the insulation board; this considerably reduced disruption and potential damage.

Electrical cables should be routed below insulation or encased in a conduit to minimise any risks of overheating. A qualified electrician should be consulted in either case. Likewise, the position of water pipes and other services should be considered before undertaking insulation work as ambient temperatures will be lower.

All suspended timber floors require free movement of air through the solum void, and especially so if the floor has been insulated. The outside ground level should be below the ventilation grilles in the masonry and corrosion or vegetation that might block airflow should be removed.

### Insulating solid floors

Due to the potential for damage, it is generally recommended that original solid floors such as flagstones are left in situ. However, where a floor is required to be lifted for another reason, or where the original features have been lost and there is a more modern concrete floor, insulation will improve thermal performance either through fixing an insulated board on top of the existing floor or by excavating and laying a new insulated lime concrete floor in its place.

*Insulation board.* A thin but high performing insulating board fixed on top of a concrete floor can greatly improve thermal performance. For example, in an Historic Scotland trial the use of a 30 mm aerogel board gave an improvement in U-value from 3.9 to 0.8 (see *Refurbishment Case Study 6*). Aerogel board can be supplied in various thicknesses, cut to size and fixed with adhesive (Fig 15). It is important to cut the board to ensure a snug fit at joints and full coverage of the floor surface. The base of doors will usually require trimming, resulting in some loss of fabric, whilst skirting boards should be removed and reinstated so as to allow full coverage of the insulation.  A new floor covering will need to be laid over the insulated board.

**Fig 15** Aerogel board being laid onto a concrete floor. Image by Changeworks.


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*Lime concrete floors.* Older concrete floors are commonly insulated by replacing an existing concrete floor with the same material laid over a phenolic foam or polystyrene insulating layer. However, whilst thermally effective this is not vapour permeable and could therefore lead to water concentration at the base of walls. Replacing a concrete floor with an insulated lime concrete floor retains the ability to absorb and release moisture whilst improving both the thermal performance and the general health of the building. Lime concrete floors have proved to be a good base for under floor heating systems and there are a range of suppliers who give specifications for the concrete work and the heating coils that go in them. Lime concrete however can take time to cure or 'set' and needs to be protected for a period of around three weeks, and as such might not be appropriate in all situations.

There are two techniques for lime concrete floors: to mix the insulating material, for example hemp or recycled glass material, within the lime concrete itself and lay as a homogenous whole (Fig 16); or to lay an insulation layer such as lightweight expanded clay aggregate (LECA) onto the solum and place a screed of lime concrete on top (Fig 17, and see also *Refurbishment Case Study 8*). In both cases, the existing concrete floor and subsoil should be excavated to a depth in the region of 300 mm, or as required by the material supplier. The soil is then levelled and compacted before a layer of geotextile is placed on the ground, and the lime concrete floor can be laid using the chosen method. Once laid, lime concrete will need to cure and be protected from frost and impact damage normally for at least two weeks, although the use of floorboards will allow continued access. When the lime concrete has cured it can be polished to a finish, or a floor covering such as flagstones bedded in lime mortar can be laid.

**Fig 16** Finishing a lime hemp floor prior to the relaying of original flagstones. Image by Simpson & Brown Architects.

**Fig 17** Outline detail for a LECA and lime concrete floor.


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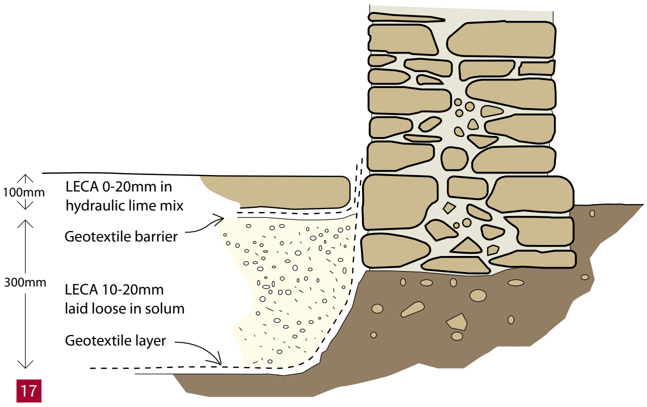

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## 3.3 Windows

### Introduction

Traditional glazing is commonly considered draughty or inefficient and therefore considered responsible for significant heat loss, yet much of the experienced draught can in fact be convection downdraughts from air contact with the cooler glass. Historic Scotland has used a range of tests to assess the thermal benefits of specific interventions, which can be carried out on traditional windows. The results are summarised in Table 1, and presented in detail in *Historic Scotland Technical Paper 1: Thermal Performance of Traditional Windows.*

From a conservation and sustainability perspective, the existing window fabric should be retained while upgrading and improving wherever possible. Sash and case windows are extremely durable and if maintained correctly will last many decades. Many timber windows in Scotland are in their second century.

A single glazing pane is not a good insulator, with a U-value of around 5.5. However many improvements can be made to the thermal performance of a window without negatively affecting the fabric or its appearance. Secondary glazing is the one of the most effective methods for improving thermal performance, reducing heat loss by 63% (U-value of 1.7 in Table 1). Used in conjunction with other methods such as blinds and shutters, a reduction in heat loss of over 75% can be achieved (U-values of around 1.0). Traditional methods such as timber shutters will also significantly improve thermal performance, reducing heat loss by 51% (U-value of 2.2).

Additional thermal improvements can be made using new double glazed units which can be retrofitted into existing window frames to minimize the impact on the character of the window. These range from thin or 'slim profile' double glazing to more advance vacuum pane technology. Such intervention may not be appropriate in certain situations, for example if the window panes retain historic glass. However, should extensive repair or replacement of windows be required then this may be a suitable option.

| Improvement method | Reduction in heat loss | U-value W/m2K |
|---|---|---|
| *Unimproved single glazing* | – | 5.5 |
| *Fitting and shutting lined curtains* | 14% | 3.2 |
| *Closing shutters* | 51% | 2.2 |
| *Modified shutters, with insulation set 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 pattern roller blind, with plain fabric* | 28% | 3.2 |
| *A "thermal" honeycomb blind* | 36% | 2.4 |
| *Victorian blind and closed 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 the existing sash* | 79% | 1.3 |

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

## Blinds, curtains and shutters

Traditional options for reducing heat loss from windows, such as blinds, curtains and shutters, can result in significant reductions in heat loss with no impact on window fabric (see Table 1). A combination of these systems can reduce heat loss by as much as 62%, only 1% less than through the installation of secondary glazing. While this will result in reduced light levels, the lowest external air temperatures and period of greatest occupancy (and therefore heat loss) is generally at night.

*Roller blinds.* Roller blinds were commonly fitted to windows in the 19th century, and in many buildings the original brass fittings are still present in the top corner of the sash case. These blinds (Fig 18) allow privacy during the day, reduced penetration of sunlight, and also retained heat. If original fittings remain these can be re-used with new fabric; alternatively, new roller blind mechanisms can be installed with no damage to the existing window fabric, in a range of modern materials with varying thermal or reflective properties.

*Curtains.* Full length, lined and well-fitted curtains can control draughts and reduce heat loss by up to 14%. Curtains have no impact on existing window fabric, although care should be taken to ensure they do not obstruct radiators.

*Shutters.* Commonly found in older buildings, timber shutters can reduce heat loss of windows by up to 51% (see Table 1). Due to cost however, many rural buildings and later tenements were not constructed with shutters and have imitation fielded panels made to look like shutters. Restoring painted-up shutters is generally straightforward; the benefits are considerable as thermal imaging can reveal (Fig 19). The thermal performance can be further improved through applying a thin layer of aerogel blanket, resulting in a 60% reduction in heat loss in trials. Such insulation can be fixed to the internal panels of the shutters, and overlain with a thin layer of plywood and new beads before painting.

Where shutters have been removed but the framing and housing remains, a new shutter can be made using either traditional joinery techniques (i.e. mortice and tenon joints with fielded panels) or by cheaper and quicker modern techniques (see *Historic Scotland Inform Guide: Timber Window Shutters*). If there is no housing or shutter case, a shutter can be fixed directly to the sash case, as sometimes seen in basements and working areas of older buildings.

If new shutters are being manufactured then they could be glazed (Fig 20) to allow them to be closed during daylight hours; in effect acting like secondary glazing but with the flexibility of a shutter. Such a solution could be particularly beneficial in commercial properties, which are occupied during daylight hours.

**Fig 18** Traditional pattern roller blinds can result in significant reductions in heat loss.

**Fig 19** Thermal image showing the benefits of shutters. Image by Changeworks.

**Fig 20** Glazed shutters in use.


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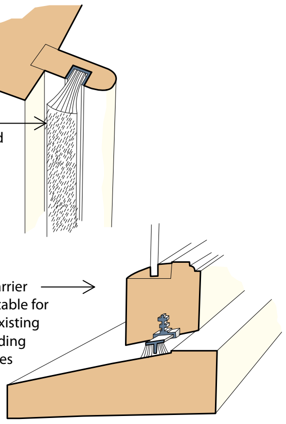

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**Fig 21** Common details for draught strips fitted to windows.

**Fig 22** Timber framed secondary glazing in a dormer window.

**Fig 23** Secondary glazing mounted within the staff beads.

## Draught proofing

A timber sash and case window in good condition will have very modest air leakage, equivalent to air infiltration through a trickle vent and as such should not need draught proofing. However where there is excess air ingress through wear and tear, draught proofing of sashes can reduce air leakage by up to 80%, although not reducing the U-value of the window itself. A range of products is available, such as brush or foam strips; the former generally considered to be the most effective and durable method. Draught proofing will result in some loss of existing fabric in the preparation of the routing channel to hold it in place (Fig 21), or the replacement of the parting beads. It is also possible to incorporate the draught proofing into the baton rods, which are commonly replaced several times in the life of a sash and case window.

Ventilation may need to be reassessed following draught proofing to avoid increased internal humidity and a potential build up of condensation on cooler areas such as glass. In cases where draught proofing is part of a wider refurbishment requiring a building warrant, the installation of trickle vents may be necessary, and listed building consent may apply. For indicative details of trickle vents in sash and case windows, see *Historic Scotland Short Guide: Sash and Case Windows.* If secondary glazing is being fitted it may be advisable not to carry out draught proofing measures to the mid rail of the window in order to allow adequate ventilation.

## Secondary glazing

Secondary glazing is essentially a second window installed internally next to the original window in order to reduce air leakage and radiant heat losses. They are available in a variety of styles and can be effective in improving U-values without the loss of existing fabric and with minimal effect on the external appearance. Most secondary glazing is made from standard profiles in aluminium, though they can be made in timber by a joiner (Fig 22).

Frames for secondary glazing can be positioned at any point along the window reveal, however it will be most discreet closest to the window. Where shutters are present, secondary glazing needs to be mounted within the staff beads of the window to allow the shutters to operate (Fig 23). Some secondary glazing can be fixed as non-opening, although consideration will need to be given to ventilation requirements.

Some proprietary systems are supplied for installation by the building owner, for example polycarbonate sheeting is supplied cut to size and is then fitted to the window reveal using magnetic tape (Fig 24). This system allows for easy removal in summer and for cleaning. Such a system should be able to achieve a U-value of around 2.4 (see *Refurbishment Case Study 2*).

Externally mounted secondary glazing systems are harder to fit to ensure a good junction with the existing frame, and may be visually more obtrusive. However, they can have a number of benefits including reducing weathering to existing windows or the kames of leaded lights, thereby reducing maintenance costs, and can offer some protection from vandalism. Such a system may be preferable in very exposed locations where the advantages of durability and protection outweigh aesthetic considerations. It is advisable to allow ventilation in the gap between the original window and secondary glazing to avoid decay or corrosion of the original window fabric. The visual impact of external secondary glazing can be considerably reduced by matching the paint colour to that of the timber window behind (Fig 25).

### Double glazed units

*Slim profile glazing.* Where appropriate, glass in sash and case windows can be replaced with thin or slim profile double glazing in existing timber sashes. Careful assessment of the historic or cultural significance of the original glass is required before this work is undertaken. For example, the removal of crown glass should be discouraged given the rarity of surviving examples and the significant visual value which this glass adds to a building elevation. Where timber frames have suffered decay, components can be repaired with new timber sections before the double glazed units are fitted (Fig 26).

When installing double glazed panels, the check or rebate in the astragal which holds the glass is made deeper by around 7mm, and the double glazed units (commonly 12.5mm thick) are then fixed into place using synthetic or natural putty. Windows should be re-painted before being re-hung, and new sash cords and sometimes heavier sash weights are required to allow balanced opening (see *Refurbishment Case Study 8*).


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**Fig 24** Polycarbonate secondary glazing.

**Fig 25** External secondary glazing.

**Fig 26** Original repaired sash with new double glazed units.

**Fig 27** Double glazed panes in a new window in Stromness.

**Fig 28** Vacuum panes fitted into existing timber sashes.

Although this process can be time consuming with much care required to avoid damage to the astragals, it can be a good way to upgrade the thermal performance of a building whilst retaining the original timber windows.

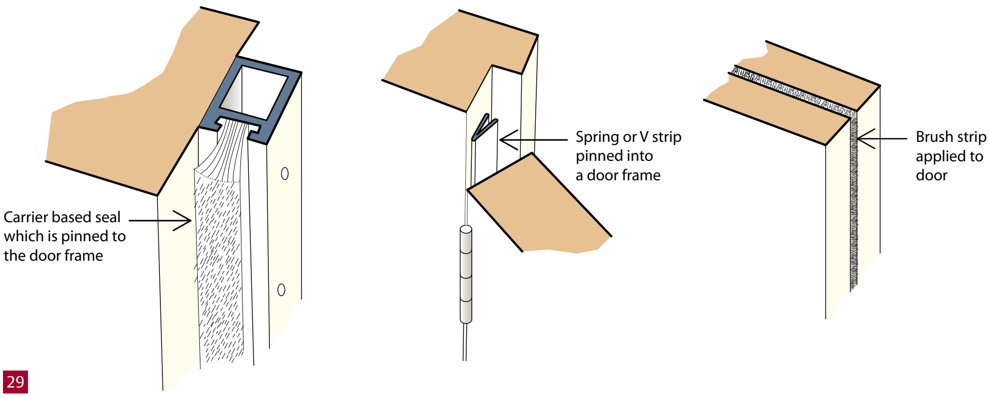
*New sashes in existing cases.* Where the timber of the sash is in poor condition and cannot be saved, yet the window case is in good or repairable condition, new sashes with double glazing can be made to fit the existing cases following the original pattern and pane sizes (see Fig 27). In some cases a single double glazed pane is used for each sash, with applied astragals fastened to the surface of the glass, however the long term durability of the applied astragals is not assured.

*Vacuum insulated glass.* Advanced versions of the double glazed units described above are available, which use vacuum technology to create thinner glazing units. These have a small metal plug where the air is evacuated, which has some negative visual impact (Fig 28). They also tend to be expensive per unit cost, and therefore may be best suited for windows with large panes such as late 19th century two pane ('one over one') windows.

## 3.4 Doors

### Introduction

Heat loss from doors can be reduced by either draught proofing around the door or insulating the fabric of the door itself. These techniques are normally used on external doors as there is usually little need to insulate internal doors unless there are significant heat differentials between rooms. Draught proofing around the edge of the door, the letterbox and covering keyholes can help to considerably reduce heat loss. Draught proofing may not be suitable where the door is of particular heritage value or when upgrading a fire door, and advice should be sought in these cases. Some indicative details for common door draught proofing are shown in Fig 29.

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*Improvements to panelled doors.* Whilst timber door frames perform well thermally, improvements can be made to the panels of doors which are often made of thinner wood. Insulation can be fitted in a single layer, or multiple thinner layers, to the inside of the door panels, maintaining the external character of the door (Fig 30).

The insulation material used should allow vapour permeability and be thin enough not to significantly alter the appearance or configuration of the door. The material should be fitted using an adhesive rather than nails or screws, before applying a thin layer of plywood and fixing new beads or moulding prior to painting (Fig 31). In the example shown in Fig 31, an improvement in U-value from 3.9 to 0.8 was achieved (see *Refurbishment Case Studies 1, 6 and 8*).

**Fig 29** Common draught proofing details for doors.

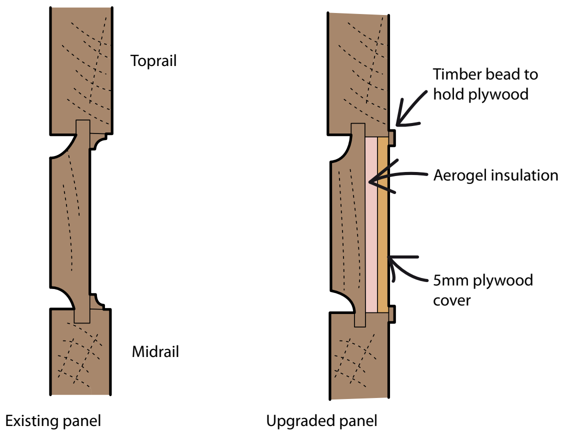


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**Fig 30** Technique for insulating door panels.

**Fig 31** A section of an insulated tenement door prior to painting.

## 3.5 Walls

### Introduction

Recent Historic Scotland research has shown that modest intervention to the internal surface of mass masonry walls can considerably improve their thermal performance. This improvement in thermal performance can be achieved using a number of methods. Some of these methods are in line with good conservation practice, are relatively cheap and less disruptive to the occupants, and also allow the retention of existing internal linings and finishes.

As discussed in section 2, traditional mass masonry walls allow moisture vapour movement through the fabric. Traditional internal renders made from hygroscopic materials also assist in buffering humidity produced by domestic occupation, and it is therefore vital that any insulation (as well as any finishing material applied over the insulation) allows this movement of water vapour to continue.

In considering a wall insulation of any type, the situation and exposure of the building to prevailing weather, especially wind driven rain, is important. Walls with high exposure should probably not be treated, without full consideration of their integrity and performance. In such cases, resources may be better spent on external detailing improvements to better manage wind driven rain.

*Internal upgrade options.* There are four broad approaches to the application of internal insulation to mass masonry walls:

- Insulation blown behind existing wall linings
- Insulation applied on existing wall linings
- Insulation applied directly to masonry or plaster
- Insulation held in place by timber framing

The method used should be largely determined by the extent and condition of the original fabric that remains. Where lath and plaster survives, there will normally be a cavity between this and the masonry wall. Where original linings have been lost, more recent dry linings can be removed and replaced with insulation, either directly to the masonry ('on the hard') or, where space allows, the wall can be framed with timber to hold insulation in place. In general, thinner materials such as calcium silicate based insulation board and aerogel based blanket are best applied directly to the masonry, whilst thicker materials such as wood fibreboard and hemp board are best held in place with framing.

It is important to avoid thermal or cold bridges when insulating a wall. These are formed where different elements of the building structure are present which lose heat at a more rapid rate, for example where thinner walls are present in a splayed window reveal. The presence of surfaces of lower temperature can lead to condensation, and possible decay of materials. In practice, it is almost impossible to fully avoid this when retrofitting insulation, but steps should be taken to minimise the risk.

*Materials.* As mentioned previously, it is vital to choose an appropriate vapour permeable material to avoid creating a vapour barrier which could lead to build up of moisture and associated decay within the wall. A natural material such as hemp or wood fibre board, a wood/wool mix, blown cellulose or sheep's wool is most likely to achieve this. Non-vapour permeable products, while thermally effective, may not be appropriate in traditionally constructed buildings as they could lead to moisture concentration and subsequent fabric decay.

*Site trials.* An Historic Scotland trial in a Glasgow tenement monitored moisture levels within the wall fabric following the installation of five different vapour permeable insulation types. The results of the first year of monitoring are summarised in Table 2 below, showing the average relative humidity levels over a year long monitoring period at the point of interface between the wall and the insulation and at a depth of 50 mm into the stone (see also *Refurbishment Case Study 4*). None of the insulation materials trialled are shown to be causing a damaging build-up of moisture at the interface between the insulation and wall, nor within the wall fabric itself. In three cases (aerogel board, hemp board and wood fibre) the relative humidity was higher than that in the room (only considerably so in the case of wood fibre), but all were within limits considered safe. Humidity for blown cellulose and bonded bead was lower at the interface and within the fabric of the wall than in the room. Importantly, whilst the results below are averages, in no cases did humidity rise significantly over the monitoring period. These results begin to prove that insulation can be safely applied directly to mass masonry walls without a vapour barrier. Further monitoring will continue over a five year period at this and other research sites to examine this issue in greater depth.

| 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 (%) |
|---|---|---|---|
| *100mm Hemp board* | *52.1* | *65.2* | *66.6* |
| *80mm Wood fibreboard* | *20.7* | *61.7* | *58.9* |
| *50mm Blown cellulose* | *21.9* | *14.8* | *14.3* |
| *50mm Aerogelboard* | *45.9* | *64.4* | *63.3* |
| *50mm Bonded polystyrene bead* | *58.3* | *16.4* | *15.8* |

**Table 2** Relative humidity readings recorded at the wall/insulation interface in the five flats. Data from Historic Scotland *Refurbishment Case Study 4*.

Thermal improvement of internal walls will be influenced by the type and thickness of material chosen and the initial conditions and materials present. Historic Scotland trials have found that good results are possible when insulating mass walls. The results using a range of insulation materials are summarised in Table 3 below.

| Insulation type | Method of installation | Unimproved U-value | Improved U-value |
|---|---|---|---|
| *80mm Wood fibre* | *Applied between timber framing* | *1.1* | *0.19* |
| *100mm Hemp board* | *Applied between timber framing* | *1.1* | *0.21* |
| *40mm Aerogel board onto metal straps* | *Applied onto metal straps* | *1.1* | *0.22* |
| *100mm Cellulose fibre* | *Sprayed damp onto masonry* | *1.1* | *0.28* |
| *50mm (approximately) Bonded polystyrene bead* | *Blown behind existing wall lining* | *1.1* | *0.31* |
| *30mm Aerogel board* | *Applied onto metal straps* | *1.1* | *0.36* |
| *100mm Wood fibre* | *Applied between timber framing* | *2.1* | *0.4* |
| *50mm (approximately) Cellulose bead* | *Blown behind existing wall lining* | *1.3* | *0.6* |
| *10mm Aerogel blanket* | *Applied directly to masonry* | *1.6* | *0.9* |
| *50mm Calcium silicate board* | *Applied directly to masonry* | *2.1* | *1* |

**Table 3** Pre and post U-values for different insulation types.

The following sections describe in further detail the four broad approaches outlined above which can be taken to insulate masonry walls, and the methods and materials which may be appropriate for each.

## Insulating behind lath and plaster

Blown materials are used to improve the performance of lath and plaster wall finishes in a similar way to the techniques used in cavity wall insulation. This allows retention of existing linings and minimises disruption to historic material as well as reducing disruption to the occupants (Fig 32). Using this method there is however, a significant reduction in the ventilation of the cavity between the lath and plaster and the masonry wall, and it is therefore vital that a vapour permeable, ideally an 'open-cell', material is used to allow modest movement of air and water vapour whilst preventing draughts behind the laths. Appropriate materials could include blown cellulose, polystyrene bead, perlite and a water based foam. If using

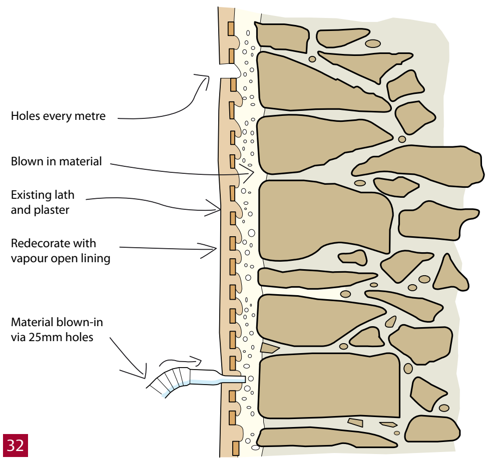


**Fig 32** Technique for blown insulation behind a lath and plaster lining.

bonded polystyrene bead there may be a need to reroute electrical wiring prior to installation as the two materials interact to break down the insulation.

When inserting or blowing this material behind lath and plaster wall linings in Historic Scotland trials, great care was taken to ensure that the wall was initially dry and able to stay dry by retaining or improving water vapour permeability. The role of external maintenance is vital in achieving this, which includes for example the proper functioning of rainwater goods such as gutters and downpipes. Modern external finishes such as cement render may compromise water vapour permeability, but where practicable all steps should be taken to ensure the best level of permeability possible. In most domestic buildings this is likely to require the removal of textured wallpapers and vinyl paint finishes revealing the bare plaster. Prior to installing the insulation, gaps in the base of the wall should be closed off to prevent material falling into voids below. This is achieved by removal of the skirting boards, and packing the lower part of the wall with a fibrous material such as wood wool or rough hemp fibre. Holes in the plaster are then made every metre to permit access for the blower nozzle. The insulation material is then blown in from successively higher levels until the ceiling is reached (Fig 33).

A thermal imaging camera can be used to ensure the insulating material has filled all the voids, or alternatively a borescope can be used (Fig 34). Any missed areas can then be filled, and the holes filled prior to redecoration or touching up. Lining paper applied with a water based paste provides a good base for the application of traditional distemper, clay or mineral paint or other permeable finish when re-decorating after the works.

Although the U-values achieved will vary considerably depending on which material is used, and factors such as the depth of void which exists between the masonry and wall lining, Historic Scotland trials have shown the use of bonded polystyrene bead in this way resulted in a U-value improvement from 1.1 to 0.32, and by using blown cellulose an improvement from 1.3 to 0.6 in one trial, and 1.1 to 0.29 in other (see *Refurbishment Case Studies 2 and 4*).

**Fig 33** Cellulose fibre being blown behind lath and plaster.

**Fig 34** Inspecting the void with a borescope during the insulation process.

### Insulation applied onto existing lath and plaster

Where concerns exist over intervention in the void behind the lath and plaster, the addition of a thin layer of insulation may be appropriate. While some thin insulation products have been available for some years, mainly as a way of controlling condensation in modern buildings, newer high performing aerogel products can be applied to the surface of lath and plaster linings to improve thermal performance, while allowing the air gap behind the plaster to function unchanged. This might be suitable where the wetting cycle of the wall is of concern, such as in an exposed location. With a total thickness of 25 mm, this measure will not significantly affect room proportions, cornice details and other finishing elements.

Aerogel-based insulation comes as either a board or a 'blanket' supplied as a roll. The blanket can be supplied in 5 mm or 10 mm thicknesses, and also has the advantage of being able to be used on curved surfaces. It is fixed to the existing wall finish with an expanded steel mesh using thermally decoupled expansion fasteners (required to prevent thermal bridging). During the installation shown in Fig 35, a timber bead was applied below the existing cornice to maintain a neat junction. Two coats of plaster are then applied on the mesh and finished with a permeable paint finish. The total thickness of this measure is in the region of 25mm. Aerogel blanket has given a range of thermal improvements in Historic Scotland trials, including one improvement in U-values from 1.6 to 0.9 (see *Refurbishment Case Studies 1 and 3*).

### Material applied directly to masonry without framing

Where a wall was originally plastered 'on the hard' there is an opportunity to insulate directly onto the existing plaster surface, minimising the impact on the room proportions and facings. Historic Scotland have trialled a calcium silicate board in this situation, although wood fibre based products and other appropriate insulation materials can also be directly fastened to a mass wall. The calcium silicate board is available in a range of thicknesses to suit site conditions and the thermal improvement sought. Existing wallpaper and paint should be stripped from the masonry (Fig 36) and a vapour permeable adhesive applied to the wall before the insulated panels are fitted in place (Fig 37).

The board is finished with two coats of plaster and a permeable paint finish. In one Historic Scotland trial this method improved U-values from 2.1 to 1 (see *Refurbishment Case Studies 3 and 6*).

**Fig 35** Aerogel insulation fixed to surface of the existing lath and plaster with a steel mesh prior to application of plaster.

**Fig 36** Removal of previous decorative layers prior to application of the board.

**Fig 37** Application of the insulating boards.


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New techniques, as yet untested by Historic Scotland, are being developed using an insulated lime plaster applied internally 'on the hard'. Such an internal finish might be suitable in some situations, especially in vernacular buildings and service areas where plaster on the hard is common. To achieve reasonable thermal improvement, 50 – 80 mm of the insulated plaster is required and it also requires total removal of existing finishes. The material is batched up and applied in layers to the desired thickness and plastered to give a smooth finish (Fig 38). Limewash or distemper are used for final decoration.

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**Fig 38** Insulated lime plaster prior to limewashing. Image by Eden Lime.

### Insulation applied within framing

Where original lath and plaster wall linings have been removed or are badly damaged, there may be space to fix new timber strapping or framing to hold a thicker board-based insulation material such as hemp, wood fibre or aerogel boards. The use of timber framing to hold insulation is a fairly well established technique in construction and there is a wide choice of appropriate vapour permeable insulation materials, available in rigid boards or more flexible batts. The depth of the framing is dictated by the thickness of the insulation products and this should be considered in relation to room features and available space. The material is placed within the framing and closed in behind plasterboard or clay board (Fig 39), showing a hemp fibre bat behind a clay board.

Some proprietary systems, such as the aerogel board, use a metal frame (Fig 40). Alternatively vertical timber studs are fixed to the wall and damp-spray cellulose is applied directly between the framing (Fig 41). Once dry the cellulose is then 'planed' flush to the strapping and covered with clay board or plasterboard.

The U-value improvement with this method will vary depending on thickness and type of materials used. Historic Scotland trials in external walls found that 100mm of wood fibreboard improved the U-value of the wall from 2.1 to 0.19; 100mm hemp board from 1.1 to 0.22; and 50mm aerogel board from 1.1 to 0.23 (see *Refurbishment Case Studies 4, 6 and 8*).

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**Fig 39** Hemp fibre insulation with clay boad.

**Fig 40** Aerogel board mounted on steel framing.

**Fig 41** Cellulose insulation being applied wet.

**Fig 42** The visual impact of external insulation.

**Fig 43** This gable end, in need of maintenance, and showing the remains of a lime render, is well placed to receive an appropriate form of thin external insulation.

**Fig 44** A wood fibreboard external render system applied to a pend in Glasgow.

## External insulation

In some situations insulating material can be applied to the external face of the masonry. Due to aesthetic considerations and difficulties in application, this approach is unlikely to be appropriate to many traditionally constructed buildings, for example where there is high quality ashlar work or a visually attractive façade. There may also be difficulties in detailing such insulation, for example at window and door reveals. Fig 42 gives an indication of the visual effects of external insulation.

Where a building has previously been rendered or harled, the application of an insulated replacement may be appropriate and practicable (Fig 43). This may be especially beneficial where an impermeable cement-based render is failing and its removal may benefit the building fabric through improved moisture handling. In many cases in Scotland, the gables and rear elevations of buildings are often architecturally less complex and may suit a thin form of external insulated render.

At present however, with materials and techniques available today, external insulation will be expensive to install and may only be effective where relatively large areas are being treated in an area based upgrade scheme. There will be situations where conventional external insulation is appropriate and, as with other interventions in this guide, it should be moisture vapour permeable. Lime based materials of this type are in their infancy and have yet to be trialled. Boards and spray-applied materials that do not allow a degree of moisture movement through the structure should not be used as these could result in a build up of moisture in the fabric of the wall. It should be noted that a building warrant is required for any application of insulation to an external wall.

For external insulation a board and render system such as the wood fibreboard may be appropriate if it allows the vapour permeability of the wall to be maintained. Fig 44 shows a wood fibreboard 40 mm in thickness applied to the walls and ceiling of a pend beneath a tenement in Glasgow. The boards need to be protected from direct moisture, and special edge and drip detailing is required to keep driven rain away from the board. Such board-based external insulation generally requires a render system to make it fully weather proof and it is important that this is also vapour permeable. The level of thermal improvement gained from the insulation shown in Fig 44 resulted in a U-value reduction of the wall from 1.3 to 0.4 (see *Refurbishment Case Study13*).

## 3.6 Chimneys and flues

### Introduction

Fireplaces (or chimneypieces) are important in providing ventilation in traditional buildings. The action of moving air within the flues draws air through the rooms and assists in removing any concentrations of moisture in the masonry, especially at exposed gable ends. Closed flues are therefore prone to an accumulation of damp if air flow is restricted and the permanent closing up of hearths is not advisable.

### Closing flues

If a fireplace is no longer used and there is a desire to close it off to reduce draughts, it is important that some form of air movement is retained. An inflated 'chimney balloon' (Fig 45), can be used to minimise draughts in the winter period, and can be removed in the summer, when increased airflow, and the associated cooling, might be required.

A chimneypiece can also be temporarily closed off with a hearth board, fitted over the opening (Fig 46). All chimney heads, whether in use or not, can be fitted with a conical vented cowl (Fig 47), to keep out rain and birds while remaining in use.

Chimneys may be able to be re-used for new heating appliances such as some modern enclosed grates, wood burning stoves and biomass micro-renewable systems. In this case, a thorough flue inspection should be carried out and any repairs undertaken to the masonry and the lining; the chimney may also need to be re-lined. Professional advice should be sought in all cases.


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**Fig 45** A chimney balloon as used to temporarily close off chimney flues.

**Fig 46** A hearth board used to temporarily close off a fireplace.

**Fig 47** A cowl used to keep chimneys dry, but ventilated and free of birds.

# 4. Conclusions


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Fig 48 The award winning project in Edinburgh.

Traditionally constructed buildings are capable of being upgraded to give a much improved level of thermal performance. This can be achieved by interventions sympathetic to both their appearance and performance. Improvements can, in many cases, be achieved without resorting to the wholesale loss of original building fabric or the use of materials which are incompatible with the character of the building, as has been demonstrated in the Historic Scotland trials programme. One of the trials, a project in association with Castle Rock Edinvar Housing Association (Fig 48), won the Carbon Trust's Low Carbon Retrofit Award in 2012.

By carefully considering the methods and materials described in the guide, the thermal performance of traditionally constructed buildings can be significantly improved. This will help to ensure that an important element of the nation's building stock has a viable future and can play its part in creating a sustainable and low carbon Scotland.

# 5. Contacts and further reading

## Contacts

Historic Scotland: 0131 668 8600 *www.historic-scotland.gov.uk*

Historic Scotland Conservation Website – Knowledge Base.
*www.historic-scotland.gov.uk/conservation*

Society for the Protection of Ancient Buildings (SPAB): 020 7377 1644
*www.spab.org.uk*

The Energy Saving Trust: 0800 512 012 *www.energysavingtrust.org.uk*

## Reading

Changeworks (2008), Energy Heritage: A guide to improving energy efficiency in traditional and historic homes, Edinburgh: Changeworks
*www.changeworks.org.uk/content.php?linkid=373*

English Heritage Saving Energy guidance:
*www.climatechangeandyourhome.org.uk/live/saving_energy.aspx*

Historic Scotland (2012), A Climate Change Action Plan For Historic Scotland
*www.historic-scotland.gov.uk/climate-change-plan-2012.pdf*

Hughes P. (1993), The Need for Old Buildings to Breathe, London: SPAB

Scottish Government (2009), Climate Change (Scotland) Act
*www.legislation.gov.uk/asp/2009/12/contents*

Scottish Government (2010), Energy Efficiency Action Plan
*www.scotland.gov.uk/Publications/2010/10/07142301/0*

The Prince's Regeneration Trust (2010), The Green Guide for Historic Buildings, London: TSO

Urquhart D. (2007), Conversion of Traditional Buildings, Edinburgh: Historic Scotland

Walker S. (2012), Energy Use in the Home, Edinburgh: Scottish Government

Wright, G.R. and Howieson, S.G. (2009), Effect of improved home ventilation on asthma control and house dust mite allergen levels, Allergy Vol. 64, No. 11, pp. 1671-1680

## Technical Papers

Our Technical Papers series disseminate the results of research carried out or commissioned by Historic Scotland, mostly related to improving energy efficiency in traditional buildings. At the time of publication the series has 20 titles covering topics such as thermal performance of traditional windows, U-values and traditional buildings, keeping warm in a cool house, and slim-profile double-glazing.

All the Technical Papers are free to download and available from the publications page on our website *www.historic-scotland.gov.uk/conservation*

## Refurbishment Case Studies

This series details practical applications concerning the repair and upgrade of traditional structures to improve thermal performance. The Refurbishment Case Studies are projects sponsored by Historic Scotland and the results are part of the evidence base that informs our technical guidance. At the time of publication there are 13 case studies covering measures such as upgrades to windows, walls and roof spaces in a range of traditional building types such as tenements, cottages and public buildings.

All the Refurbishment Case Studies are free to download and available from the publications page on our website *www.historic-scotland.gov.uk/conservation*

## INFORM Guides

Our INFORM Guides series provides an overview of a range of topics relating to traditional skills and materials, building defects and the conservation and repair of traditional buildings. At the time of publication the suite has over 45 titles covering topics such as: ventilation in traditional houses, maintaining sash and case windows, domestic chimneys and flues, damp causes and solutions improving energy efficiency in traditional buildings, and biological growth on masonry.

All the INFORM Guides are free to download and available from the publications page on our website *www.historic-scotland.gov.uk/conservation*

# 6. Glossary

For more information on Scottish building terms, see Dictionary of Scottish Building by Glen Pride, Rutland Press 1996.

**Aerogel:** *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.*

**Architrave:** *The mouldings framing a door or window.*

**Astragal:** *The bars in a window that separate and hold the individual panes of glazing.*

**Batt:** *Semi rigid insulation board.*

**Calcium silicate board:** *A rigid, micro porous mineral board. Its high capillary action assists in humidity regulation. The nature of the material means that mould cannot form on its surface.*

**Cellulose insulation:** *Formed of cellulose fibre commonly derived from recycled newspapers. It can either be used blown in to cavities, laid as loose fill or applied directly to a wall through damp spraying.*

**Chimneystack:** *The part of the chimney that rises above the roof of the building, often containing a number of flues.*

**Condensation:** *The formation of liquid water on a surface from a gas or vapour state due to the air temperature falling below its dew point.*

**Cold roof:** *The method of applying insulation above a ceiling in a loft space so that everything above the insulation is colder than that below, hence the term cold roof.*

**Cornice:** *A decorative horizontal moulding that runs along the junction of internal wall ceilings.*

**Coom ceiling:** *A Scottish term for a sloping ceiling, the upper side of which forms part of the roof of the building.*

**Cold bridge:** *Sections of building fabric which have considerably lower thermal resistance than neighbouring areas when, for instance, an element travels from the interior to the exterior surface of a building element or where an area is insufficiently well insulated.*

**Dew point:** *The dew point is the temperature where the water vapour in a volume of humid air at a constant barometric pressure will condense into liquid water.*

**Draught proofing:** *Is the process of reducing air leakage in the frames of windows, doors or loft hatches.*

| | |
|---|---|
| **Dry lining:** | *A wall lining commonly formed of plasterboard on timber studs, which does not need to be plastered.* |
| **Dwang:** | *A Scottish term for a transverse piece of wood inserted between joists or posts in order to stiffen them.* |
| **Eaves:** | *The lower edges of a roof that usually project over a side wall in order to carry rain water away from the fabric.* |
| **Geo textile:** | *Geotextiles are moisture vapour permeable artificial fabrics.* |
| **Harling:** | *Scottish term for the application of an exterior render of roughcast comprised of lime and aggregate.* |
| **Hemp board:** | *A rigid board based insulation formed of fibers from hemp plants. Hemp / wool insulation is a semi rigid insulation formed of a mixture of hemp and wool fibres.* |
| **Hygroscopic:** | *A material which can absorb and release moisture.* |
| **Hydrophobic:** | *Incapable of absorbing moisture.* |
| **Jamb:** | *The vertical side posts used in the framing of a doorway or window. The outer part of the jamb, which is visible, is called the reveal.* |
| **Joist:** | *A beam supporting the floor or roof, which is normally made of timber.* |
| **Kames:** | *Strips of lead, which hold the glass in place in a leaded light.* |
| **Lath and plaster:** | *The building process used for lining internal walls from the 18th century up until the mid 20th century. Vertical timber battens are fixed to the masonry; thin timber laths are then horizontally mounted. Three coats of lime plaster completes this lining. The gap behind the laths and plaster is normally 25 – 30mm.* |
| **Leaded light:** | *A window formed of a lattice of small panes and held within strips of lead known as kaimes.* |
| **LED lighting:** | *Light-emitting diodes emit visible light when electricity is passed through them. They are a form of energy efficient lighting.* |
| **Lime concrete:** | *A concrete formed of aggregate with lime rather than cement as the binder.* |
| **Mansard roof:** | *A roof which has two slopes on each side, the lower slope being longer and steeper than the other and often incorporating dormer windows to allow the roof space to be inhabited.* |
| **Mass masonry:** | *Masonry formed of material such as stone, brick or earth without a cavity separating the inner and outer parts of the wall.* |
| **Mineral paint:** | *A moisture vapour permeable paint finish.* |

**Mineral wool insulation:** *A type of thermal insulation made from an inorganic fibrous substance that is produced by steam blasting and cooling molten glass, slag or rock.*

**Water vapour permeable:** *The ability of water vapour to diffuse through a material.*

**Phenolic foam:** *A synthetic polymer made from thermosetting foam plastic and used in thermal insulation.*

**Plaster 'on the hard':** *The application of lime plaster directly onto the surface of masonry walls without any laths.*

**Rafter:** *A sloping timber extending from the wall plate to the ridge of a roof.*

**Relative humidity:** *The term used to describe the amount of water vapour existing within a mixture of air and water vapour and expressed as a percentage.*

**Reveal:** *The part of the jamb between the frame and the outside wall, which is revealed, inasmuch as it is not covered by the frame.*

**Ridge:** *A horizontal line caused by the junction of two sloping roof surfaces.*

**Sarking:** *A continuous layer of timber boards onto which slates or tiles are laid.*

**Secondary glazing:** *A second window installed internally next to the original window.*

**Sheep's wool insulation:** *A flexible insulation formed of wool with a small percentage of polyester binder.*

**Sustainability:** *The long term responsible management of resource use, encompassing environmental, economic and social dimensions to allow for the endurance of said resources.*

**Skew:** *Scottish term for the coping stones that run along the top of a sloping gable.*

**Skirting:** *A finishing board, which covers the joint between the wall and the floor of a room.*

**Solum:** *The vacant area underneath a suspended timber floor.*

**Staff beads (window):** *A moulded or beaded angle of wood or metal set into the corner of plaster walls to protect the external angles of the two intersecting surfaces.*

**Suspended timber floor:** *This is a floor suspended above ground level, usually consisting of timber joists spanning the ground floor, supported by sleeper walls which allows air ventilation and prevents dry or wet rot occurring on the timber.*

**Thermostat:** *A device that senses temperature and is used to maintain a constant temperature.*

**Trickle vent:** *A small opening in a window or building component to allow for ventilation, where natural ventilation should occur but may be impinged.*

**U-value:** *The measurement of the rate of heat loss through a building component, the lower the U-value the less heat is lost through that building element. U-value is expressed in W/m$^2$K.*

**Warm roof:** *Insulation is usually placed on or adjacent to the roof rafters, so that everything below the insulation is as warm as the rooms in the house.*

**Window case:** *The framework of a window that holds the sash in place. Often referred to as a 'sash case'.*

**Window sash:** *The timber frame around the glass in a window. The term is used almost exclusively to refer to windows where the glazed panels are opened by sliding vertically, or horizontally hence the term sash and case window.*

**Wood fibreboard:** *Rigid insulating board, available in various forms and is made from a wood based material.*

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