Historic England

Energy Efficiency and Historic Buildings

Insulating Thatched Roofs

This guidance note has been prepared and edited by David Pickles. It forms one of a series of thirteen guidance notes covering the thermal upgrading of building elements such as roofs, walls and floors.

First published by English Heritage March 2012.
This edition (v1.1) published by Historic England April 2016.

Illustrations drawn by Simon Revill.

Our full range of guidance on energy efficiency can be found at:
HistoricEngland.org.uk/energyefficiency

Front cover:
Thatch repairs in progress.
© Philip White.

Summary

This guidance provides advice on the principles, risks, materials and methods for insulating thatched roofs. There are estimated to be about fifty thousand thatched buildings in England today, some of which retain thatch which is over six hundred years old. Thatching reflects strong vernacular traditions all over the country.

Well-maintained thatch is a highly effective weatherproof coating as traditional deep thatched eaves will shed rainwater without the need for any down pipes or gutters. Locally grown thatch is a sustainable material, which has little impact on the environment throughout its life-cycle. It requires no chemicals to grow, can be harvested by hand or using traditional farm machinery, requires no mechanical processing and therefore has low embodied energy and can be fixed using hand tools. At the end of its life it can be composted and returned to the land.

Thatch has a much greater insulating value than any other traditional roof covering. With the right choice of material and detailing, a well-maintained thatched roof will keep a building warm in winter and cool in summer and has the added advantage of being highly sound-proof.

The guidance stresses that changes to improve the energy performance of thatched roofs should only be attempted where really necessary as many thatched buildings already provide adequate thermal performance and where the traditional 'breathable' performance of the building will not be compromised.

Contents

Introduction

Energy Planning

Before contemplating measures to enhance the thermal performance of a historic building it is important to assess the building and the way it is used in order to understand:

- the heritage values (significance) of the building
- the construction and condition of the building fabric and building services
- the existing hygrothermal behaviour of the building
- the likely effectiveness and value for money of measures to improve energy performance
- the impact of the measures on significance
- the technical risks associated with the measures

This will help to identify the measures best suited to an individual building or household, taking behaviour into consideration as well as the building envelope and services.

Technical Risks

Altering the thermal performance of older buildings is not without risks. The most significant risk is that of creating condensation which can be on the surface of a building component or between layers of the building fabric, which is referred to as 'interstitial condensation'. Condensation can give rise to mould forming and potential health problems for occupants. It can also damage the building fabric through decay. Avoiding the risk of condensation can be complex as a wide range of variables come into play.

Where advice is given in this series of guidance notes on adding insulation into existing permeable construction, we generally consider that insulation which has hygroscopic properties is used as this offers a beneficial 'buffering' effect during fluctuations in temperature and vapour pressure, thus reducing the risk of surface and interstitial condensation occurring. However, high levels of humidity can still pose problems even when the insulation is hygroscopic. Insulation materials with low permeability are not entirely incompatible with older construction but careful thought needs to be given to reducing levels of water vapour moving through such construction either by means of effectively ventilated cavities or through vapour control layers.

The movement of water vapour through parts of the construction is a key issue when considering thermal upgrading, but many other factors need to be considered to arrive at an optimum solution such as heating regimes and the orientation and exposure of the particular building.

More research is needed to help us fully understand the passage of moisture through buildings and how certain forms of construction and materials can mitigate these risks. For older buildings there is no 'one size fits all' solution, each building needs to be considered and an optimum solution devised.

Technical Details

The technical drawings included in this guidance document are diagrammatic only and are used to illustrate general principles. They are not intended to be used as drawings for purposes of construction.

Older buildings need to be evaluated individually to assess the most suitable form of construction based on a wide variety of possible variables.

Historic England does not accept liability for loss or damage arising from the use of this information.

1 Thatched Roof Construction

Thatched roofs are as ancient as civilisation and are intrinsically linked with our agricultural past. Straw, a waste product from cereal production was the most common thatching material but in areas adjacent to water, such as the Fens and Broads, reed was also used. Other materials such as heather, gorse and ferns were also used in other parts of England.

Thatch fell out of favour in densely populated urban areas where it was a fire risk. In rural areas, the threshing machines kept thatch plentiful and cheap until the railways of the industrial revolution brought Welsh slate to most areas of the country and thatching started to decline.

Figure 1
Thatched roofs have a much greater insulating value than any other traditional roof covering. A well maintained thatched roof will keep a building warm in winter and cool in summer and has the added benefit of being highly sound-proof.
© Edifice.

1.1 Thatch covering

The styles of thatch most likely to be encountered on a roof today are long straw, combed wheat reed and water reed. These all have different performance characteristics and have to be fixed slightly differently. Consent is usually required to change the type of on a listed building.

Long straw

Today this is mainly winter wheat grown specifically for the purpose, sometimes by the thatchers. Modern varieties of wheat cannot be used because the straw is too short. Long straw thatch is often said to have a 'poured on' texture. Eaves are cut to shape and verges are either cut or rolled. Traditionally long straw is a 'multi-coat' material as the primary coat is seldom removed and successive coats added when the top layer wears down. Historically, long straw roofs are ridged in the same material with the straw wrapped over to form the ridge. Hazel rods, often forming a pattern over the top, hold the ridge in place.

Water reed

Water reed is harvested from natural reed beds. About three quarters of the water reed used in England today is imported from France, Hungary or Turkey or from further afield.

Traditionally water reed is a 'one coat' material, and since it follows the roof structure tends to create a neater more angular appearance than either long straw or combed wheat reed. In East Anglia this is partly because the tradition has always been to totally strip the old reed and re-thatch with new. As reed is a relatively inflexible material, it cannot be dressed over a ridge, so the ridges on a reed roof are usually of a different material such as sedge or straw, often in a block pattern.

In recent times, imported water reed has been championed as a superior material as it is easier to use and requires less preparation. It also requires minimal maintenance and possibly has a longer life span than long straw or combed wheat reed. For this reason, many thatched buildings previously covered with straw have been inappropriately re-thatched in water reed. However, the whole issue of longevity and performance is hotly disputed amongst the thatching community and at present, there is a dearth of independent research on the subject.

Combed wheat reed

Combed wheat reed is long stemmed straw which has been 'combed' and threshed. All the butts face the same way so the resulting roof looks similar to water reed.

1.2 Repairs

Areas of decay in a thatched roof can be removed and patch-repaired. It is common practice for both long straw and combed wheat reed roofs to have just the decayed top surfaces removed and then to be over-coated (spar coated) rather than stripped completely to the rafters. The spar coat is fixed to the layer beneath it with twisted hazel spars. The practice of over-coating saves both time and materials, and has led to many older roofs being composed of layers many hundreds of years old. Such roofs contain an important archaeological and botanical record, showing a complete picture of agriculture and plant types throughout their life.

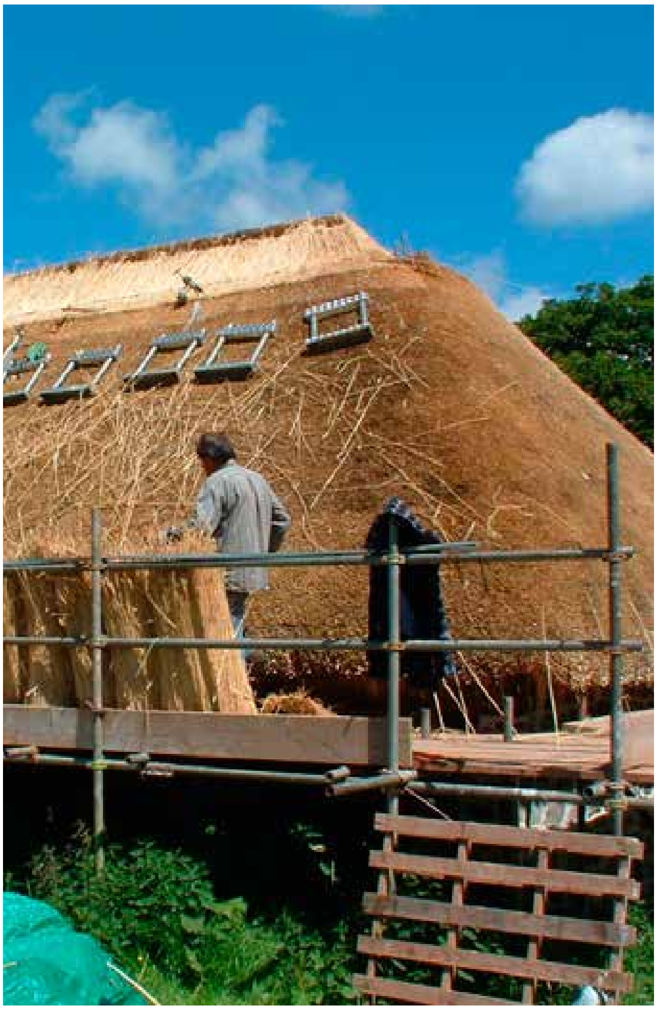
On very old thatch, there is sometimes evidence of smoke-blackening on the inside, remnants of medieval times when there was no first floor and smoke went directly into the roof. The smoke kept the thatch dry and helped to preserve it by discouraging both rot and pests. There are thought to be no more than about two hundred

Figure 2 (left)
Repairs being carried out in long straw.

Figure 3 (centre)
Repairs being carried out in water reed.

Figure 4 (right)
Repairs being carried out in combed wheat reed.

and fifty surviving examples of smoke-blackened thatch in this country, most of these in listed buildings, where it would be an offence to remove it without consent. Unfortunately, today it is common practice to strip back the thatch to the rafters to re-secure firm fixings; this practice accounts for the unnecessary loss of many smoke-blackened thatches as well as historic roof timbers.



Figures 5-6 (top and right)
Thatch repairs in progress.
© Philip White.

Figure 7 (bottom)
Smoke blackened thatch is now very rare and should be retained.
© John B Letts.

1.3 Roof structure

Thatch is found on several different types of timber roof construction. These vary depending upon the age of the building, its structural form and the local traditions. The roof structure of a thatched building is often relatively insubstantial. It is common to see pole rafters or very slender sections still with sapwood and bark attached in a loft space.

Thatching is sometimes combined with other roofing methods, even within the same slope. For example, it is common practice in the Cotswolds to lay the thatch above and over an eaves course of stone slates. Such combinations of roof materials can create further complexities for draught-proofing, waterproofing and the insulation of a building.

1.4 Internal finishes to thatched roofs

Some thatched roofs are open to the underside of the rafters, but where the space under the roof is used for habitable accommodation then internal finishes are normally applied either over the rafters or between them.

Examples of the following may be found:

Torching: Mortar-coating applied to the underside of the thatch itself, either in an earth daub or a lime plaster. The torching reduced draughts and gave an internal finish.

Boarded Ceilings: Close-boarding above the rafters can be left exposed to the underside, examples can be found in many 19th century buildings.

Lath and plaster ceilings and partitions: Many roofs were under-drawn with earth or lime plaster fixed to laths or wattles. In many cases the plaster is contemporary with the construction of the building and is an important part of its history.

Any historic internal finishes such as these on the underside of pitched roofs should be retained. This means that the design of any roof insulation will have to be carefully considered, or that insulation at rafter level may be inappropriate.

2 Energy Efficiency Measures

2.1 Thermal properties of thatched roofs

Thatch is a good insulator, keeping buildings warm in winter and cool in summer. The actual degree of insulation provided by the thatch will depend upon both the type of material and how it is fixed. A reed thatch with its strong quill-like structure will allow greater air infiltration and heat loss than a long straw thatch where the straw is compacted by the action of threshing and is fixed fairly tightly against the roof. Combed wheat reed will fall somewhere in between. The better the condition of the thatch, the better will be its insulation qualities. The tradition of over-coating in particular, with the build-up of layers of long straw thatch, has created very effective insulating roof coverings. Examples of theoretical thermal transmission (U-values) for typical thicknesses of thatch are as follows:

Overall 'U-values' will vary according to actual thickness and density.

- 300mm thickness of Water Reed – 0.29 W/m^{2}K
- 300mm thickness of Long Straw – 0.23 W/m^{2}K

Source: Based on conductivities from CIBSE Guide A3.

For comparison, the standard in Part L of the Building Regulations (2010) for replacement roofs insulated at rafter level is 0.18 W/m^{2}K. It is therefore clear that a typical thatched roof on its own can come close to meeting modern standards for thermal insulation. A roof that has been over-coated rather than stripped will often have many layers of thatch and will therefore give even better U-values and most will require no upgrading at all. This is recognised in the Building Regulations which allows exemptions and special considerations for historic buildings and buildings of traditional construction.

U-Values

U-values measure how quickly energy will pass through one square metre of a barrier when the air temperatures on either side differ by one degree.

U-values are expressed in units of watts per square metre per degree of temperature difference W/ m^{2}K

However, the thermal performance of a thatch roof is complicated and varies according to the thickness, pitch and moisture content of the thatch. It is important to understand the performance (including ventilation) of a thatch roof before considering any improvements.

The actual warmth of any enclosed space is affected both by the insulating value of the material enclosing it and the amount of ventilation or air infiltration. Thatched roofs can become very draughty due to infiltration through areas of the thatch itself or at its junctions with other materials. It is these draughts which cause both the biggest loss of heat and the greatest discomfort for occupants.

The condition of the roof is important for the maintenance of its thermal performance. A thatched roof in poor repair will not be as effective as an equivalent one in good repair and will usually allow significantly more air infiltration. Eaves, verges and abutment details which have not been maintained will be much less effective at preventing the passage of both water and air. Saturated thatch is a less effective insulating material and a roof where the water saturates more than the top 50mm of the material will lose more heat and require greater ventilation to maintain its condition than a roof where the water runs off efficiently. Vermin and bird holes may let heat out and weather in.

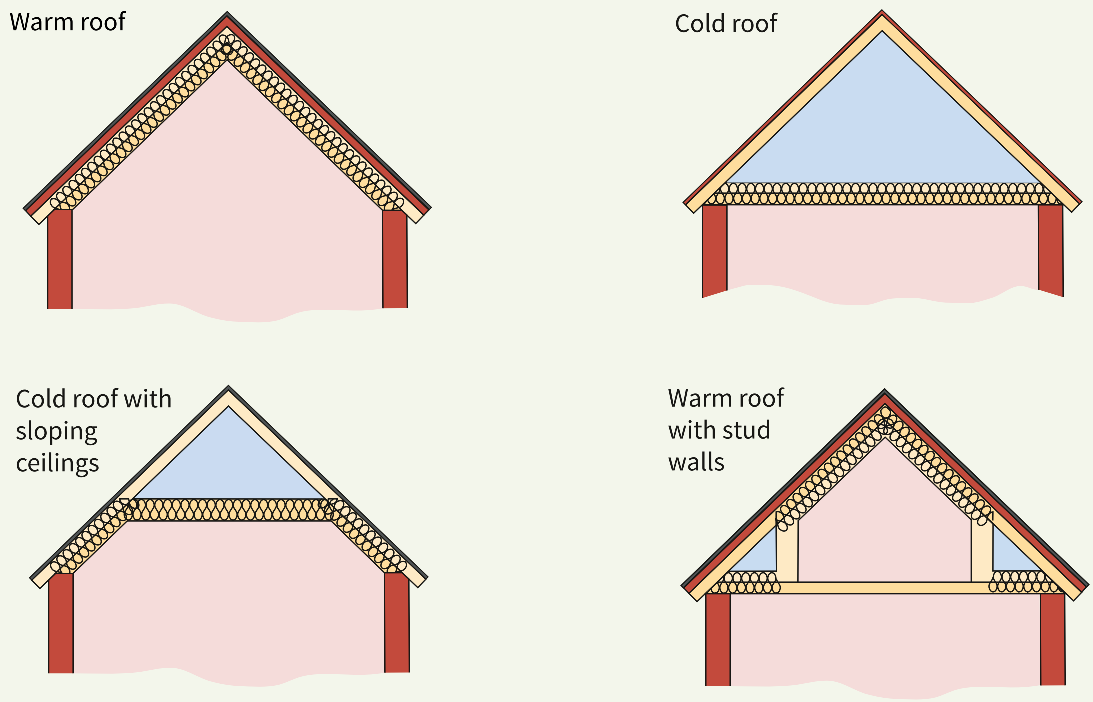
2.2 Cold roof or warm roof?

Many pitched-roof buildings have insulation laid on top of the horizontal ceiling to the top floor, leaving a ventilated, un-insulated roof space above. This is known as a 'cold roof'. Other pitched-roof buildings have insulation added along the sloping rafters, creating habitable accommodation beneath. This is often referred to as a 'warm roof'.

A thatched roof can be extremely energy efficient provided there is sufficient thickness of the right material, adequate weatherproofing and it is well-maintained. In these circumstances, the addition of further insulation will have little benefit. However, if the thatch is relatively thin, or if there are numerous gaps where air is infiltrating that would be difficult to block, and if the space directly under the roof is not required for habitable accommodation, it may be best to treat the roof as a cold roof and add insulation at ceiling level.

Warm Roofs and Cold Roofs

In this guidance the term 'cold roof space' or 'cold roof' is used to describe a pitched roof with insulation at the level of the horizontal ceiling of the uppermost floor, leaving an unheated roof space (attic or loft) above the insulation. In contrast a 'warm roof space' or 'warm roof' has insulation between or just under or over the sloping rafters, so that the whole of the volume under the roof can be heated and used. Some buildings have combinations of these two arrangements.



3 Thatched Roofs as Warm Roofs

It is very important that warm roofs are created using vapour-balanced construction, an approach that is most compatible with the performance characteristics of traditional buildings.

Insulation can be provided to thatched roofs above, between and just below pitched rafters. Because thatch itself has insulating qualities, less insulation needs to be added to a thatched roof than to a tile or slated roof, but combinations of insulation in different positions may still be necessary.

If the decision is made to treat a thatched roof as a ‘warm roof’, the first energy efficiency measures should concentrate on optimising the performance of the existing thatch by looking at areas where most heat loss is taking place. A fan pressurisation test will pinpoint the worst areas of air leakage which can then be sealed with vapour permeable materials. In many cases simple repairs can deliver acceptable levels of thermal performance without the addition of further insulation. However, if the thatch still lacks a reasonable insulating value then the addition of extra insulation can be considered beneath the thatch.

It is wise to look at areas within the thatch where non-insulating materials are used such as tiled slopes over dormers or beneath lead-lined valley gutters that may be causing more heat to be lost. Often these are the least thermally efficient areas of a thatched roof and therefore local upgrading is beneficial. As such materials are far worse insulators than thatch they need additional insulation to prevent a local ‘cold bridge’ forming underneath them. The interface between the thatch and other materials is also a potential source of air infiltration and heat loss, as such joints are difficult to make reasonably airtight.

Condensation in roofs

All air contains some water vapour, but warm air can hold more water vapour than cold air. When warm, damp air is cooled it will reach a temperature at which is cannot hold all the vapour within it, and the water will condense out. This temperature is called the dew point.

Warm damp air passing over a cold surface will be cooled locally below the dew point and condensation will take place. This effect causes the familiar condensation on the inside of cold windows.

Sections where insulation is missing or ineffective are called 'thermal bridges'. Common thermal bridges in roofs insulated at the rafters include:

- around the rafters, particularly to the top face where there is no sarking insulation above
- joints and gaps between individual sarking insulation boards
- joints and gaps between the sarking insulation and abutting walls, chimneys etc
- around pipes, cables and light fittings that penetrate the roof

In winter, thermal bridges will be cold. Warm, moist air passing over a thermal bridge will cause condensation to occur at the bridge. Often this causes spots of mould growth, which are both unsightly and potentially hazardous to health. Condensation forming near structural timbers can be absorbed into the timbers increasing the risk of active timber decay.

The risks to any particular building will be dependent on a number of influencing factors, with perhaps the most significant being the amount of water vapour being produced. The greater the intensity of use the greater the risk of problems will be. The more people there are in the building producing water vapour from breathing, cooking and bathing – particularly the use of showers – the more likely that poor detailing will be exposed and problems suffered, such as thermal bridging and condensation.

3.1 Adding insulation from above

The addition of insulation from above should only ever be considered if it is essential for a thatched roof to be stripped back to the rafters. Complete stripping is often undertaken where it is not necessary. In many cases over-coating is more appropriate, giving greater thermal efficiency with less cost. If the building is listed, consent will usually be required to strip back thatch to the rafters.

If the roof covering has to be stripped it may be possible to add insulation between the rafters provided that they are substantial enough to accommodate it. The most appropriate materials for insulating between rafters that are currently readily available are natural fibre-based insulation, such as sheep's wool or hemp-fibre. These types of insulation are able to absorb moisture in damp conditions and then let it evaporate when the environmental conditions change. This is particularly important where the timbers are vulnerable to rot or insect attack, for example old softwood pole rafters with substantial sapwood outer layers. Insulation materials such as mineral wool, fibre-glass and in particular closed cell polyisocyanurate (PIR) or polyurethane foams are inappropriate for these conditions.

It is possible to add insulating sarking boards above the rafters, possibly in combination with insulation added between the rafters.

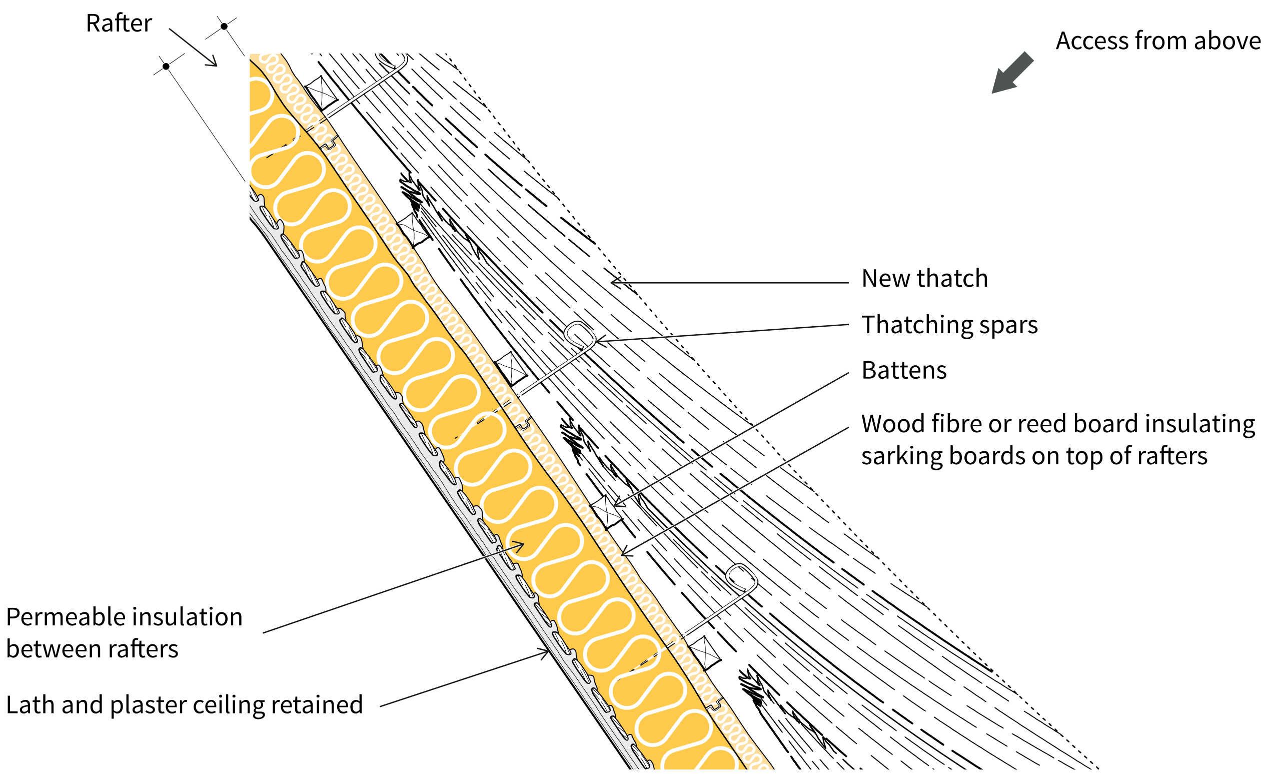


Figure 8: Warm roof – sloping ceiling (adding insulation from above, when thatch is stripped entirely)
This shows insulation added between rafters as well as sarking insulation on top of the rafters when access has been available from above following the complete stripping of existing thatch. Only vapour permeable insulation should be used in this situation. The rafters might be quite irregular in which case some levelling will be required for any boarded material placed above the rafters.

Sarking boards can considerably improve the air-tightness of the overall roof but conventional vapour-impermeable foamed materials could well cause moisture build-up and condensation leading to rot. However, vapour-permeable sarking materials such as wood-fibre and reed boards can be laid with a base coat before laying the weathering coat on top. The base coat acts as a buffer, allowing the thatch and the boarding to act as one insulating layer. Wood-fibre board provides a better thermal performance but reed board is slightly more flexible.

If the roof timbers are uneven it may not be possible to add rigid boards above the rafters without first adding furring timbers to even out the slopes. In certain circumstances the addition of firrings could harm the character of the roof.

3.2 Adding insulation below the rafters

An insulated ceiling layer can be added to the underside of rafters where sloping ceilings are not of any historic value or are badly damaged. Alternatively, an insulating ceiling could be added beneath an existing ceiling if it is a problem to add sufficient insulation between or above the rafters. This presumes that the existing ceiling is of little historic value. The biggest advantage of a new ceiling is that it will allow air infiltration to be blocked without removing the thatch.

It is also possible to install insulation between the rafters from below. However, when upgrading from below there is a greater risk of leaving gaps between the insulation and the rafters, or between the insulation and the ridge, causing 'cold bridges'.

Fire in thatch

Fire can spread very quickly through thatch. There are sensible precautions which should be taken to reduce the risk:

- Any solid fuel burnt in boilers, stoves or fireplaces needs to be thoroughly dry
- Do not fit spark arrestors to the top of chimneys as these contain embers which can drop onto thatch below
- Have electric wiring tested frequently, and keep the wiring itself well away from thatch. Fit surface rather than recessed fittings anywhere near the thatch. Do not install ventilation fans anywhere near the thatch
- Fit a mains wired smoke detector in the loft space linked to one below which can be seen
- Fit a loft hatch large enough to fit a fireman and his equipment through
- Fit a standpipe for a hose in the garden
- Keep barbeques, outdoor heaters and bonfires well away from the thatch
- The most common cause of thatch fires is heat transfer through chimneys. Chimneys should be well maintained, with all joints fully pointed, and swept at least twice a year. Chimneys should be lined especially if the heat source is a wood burning stove
- Ensure that the Fire Brigade know where your property is if the building is quite remote

Whenever it is proposed to add extra insulation immediately below a thatched roof covering, particularly if there is to be no ventilated space under the thatch, it is recommended that expert advice be taken on the risk of increasing condensation occurring within the build-up of the roof covering. Although small amounts of condensation can be briefly tolerated in a permeable form of construction, persistent moisture within these materials can be very damaging.

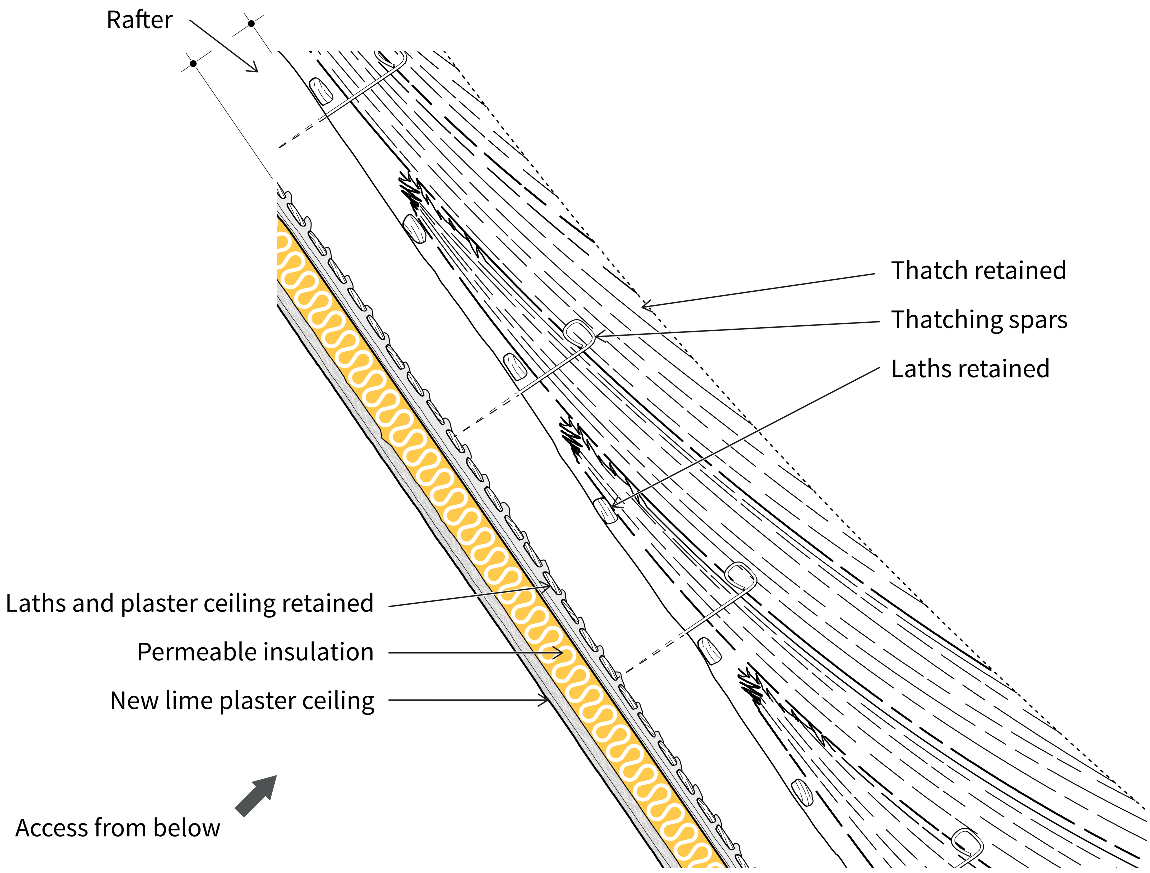


Figure 9: Warm roof – sloping ceiling (adding insulation from below – thatch retained)
Where thatch is repaired and substantially left in-situ (spar coated) then access will only be available from beneath the rafters. Many thatched buildings have rooms within the roof- space consequently insulation will often have to be placed beneath the sloping rafters. This shows an existing lime plaster ceiling retained and insulation placed below.

4 Thatched Roofs as Cold Roofs

If it is not feasible or desirable to add insulation to a thatched roof at rafter level, and if the roof-space directly beneath the thatch is not needed for habitable accommodation, then insulation can be added above the horizontal ceiling of the top floor to form a 'cold roof'. This is one of the easiest and cheapest means of improving the energy efficiency of buildings. It is of course only necessary if the existing thatch is not giving good thermal performance or new ventilation has affected this. How to create a cold roof in a traditional building, be it tiled, slated or thatched, is discussed in detail in Insulating pitched roofs at ceiling level in this series.

Traditionally thatched roofs had very little ventilation as gaps at eaves and abutments were filled with straw dollies or clay infill. Moisture was buffered by the permeable materials found in the roof, mainly timber, plaster and thatch. In more recent times the eaves have been opened up which has resulted in more outside air entering the roof space so that the thermal benefits of the thatch has been reduced. Insulation at ceiling level may well be justified in such instances. In the late 1990s there were fears that some thatch roofs were failing because of premature degradation of the underside. It was presumed that this was due to excessive moisture build up in the roof, so the obvious solution was to introduce ventilation. It now seems that other factors may have been responsible for the problems with the thatch.

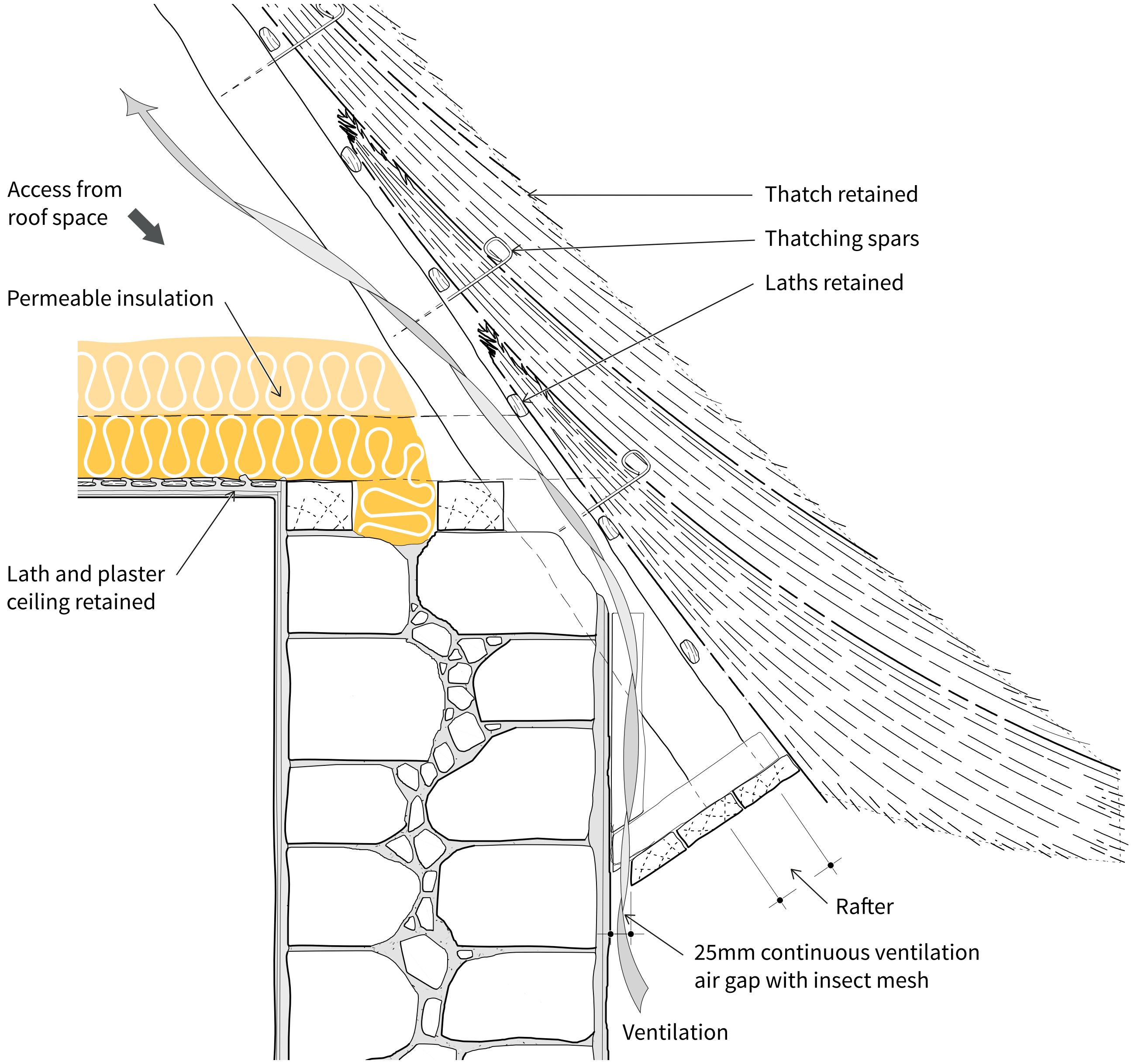


Figure 10: Cold roof – Roof space insulation at eaves
A conventional cold roof in a thatched building with a clear ventilation path maintained at the eaves.

5 Where to Get Advice

This guidance forms part of a series of thirteen documents which are listed below, providing advice on the principles, risks, materials and methods for improving the energy efficiency of various building elements such as roofs, walls and floors in older buildings.

This series forms part of a wider comprehensive suite of guidance providing good practice advice on adaptation to reduce energy use and the application and likely impact of carbon legislation on older buildings.

The complete series of guidance is available to download from the Historic England website: HistoricEngland.org.uk/energyefficiency

Roofs

- *Insulating pitched roofs at rafter level*
- *Insulating pitched roofs at ceiling level*
- *Insulating flat roofs*
- *Insulating thatched roofs*
- *Open fires, chimneys and flues*
- *Insulating dormer windows*

Walls

- *Insulating timber-framed walls*
- *Insulating solid walls*
- *Insulating early cavity walls*

Windows and doors

- *Draught-proofing windows and doors*
- *Secondary glazing for windows*

Floors

- *Insulating suspended timber floors*
- *Insulating solid ground floors*

For information on consents and regulations for energy improvement work see historicengland.org.uk/advice/your-home/saving-energy/consent-regulations/

5.1 Contact Historic England

East Midlands
2nd Floor, Windsor House
Cliftonville
Northampton NN1 5BE
Tel: 01604 735460
Email: eastmidlands@HistoricEngland.org.uk

East of England
Brooklands
24 Brooklands Avenue
Cambridge CB2 8BU
Tel: 01223 582749
Email: eastofengland@HistoricEngland.org.uk

Fort Cumberland
Fort Cumberland Road
Eastney
Portsmouth PO4 9LD
Tel: 023 9285 6704
Email: fort.cumberland@HistoricEngland.org.uk

London
1 Waterhouse Square
138-142 Holborn
London EC1N 2ST
Tel: 020 7973 3700
Email: london@HistoricEngland.org.uk

North East
Bessie Surtees House
41-44 Sandhill
Newcastle Upon Tyne NE1 3JF
Tel: 0191 269 1255
Email: northeast@HistoricEngland.org.uk

North West
3rd Floor, Canada House
3 Chepstow Street
Manchester M1 5FW
Tel: 0161 242 1416
Email: northwest@HistoricEngland.org.uk

South East
Eastgate Court
195-205 High Street
Guildford GU1 3EH
Tel: 01483 252020
Email: southeast@HistoricEngland.org.uk

South West
29 Queen Square
Bristol BS1 4ND
Tel: 0117 975 1308
Email: southwest@HistoricEngland.org.uk

Swindon
The Engine House
Fire Fly Avenue
Swindon SN2 2EH
Tel: 01793 445050
Email: swindon@HistoricEngland.org.uk

West Midlands
The Axis
10 Holliday Street
Birmingham B1 1TG
Tel: 0121 625 6870
Email: westmidlands@HistoricEngland.org.uk

Yorkshire
37 Tanner Row
York YO1 6WP
Tel: 01904 601948
Email: yorkshire@HistoricEngland.org.uk

We are the public body that looks after England's historic environment. We champion historic places, helping people understand, value and care for them.

Please contact
customers@HistoricEngland.org.uk
with any questions about this document.

HistoricEngland.org.uk

If you would like this document in a different format, please contact our customer services department on:

Tel: 0370 333 0607
Fax: 01793 414926
Textphone: 0800 015 0174
Email: customers@HistoricEngland.org.uk

Please consider the environment before printing this document

HEAG079
Publication date: v1.0 March 2012 © English Heritage
Reissue date: v1.1 April 2016 © Historic England
Design: Gale & Hayes/Historic England

< < Contents