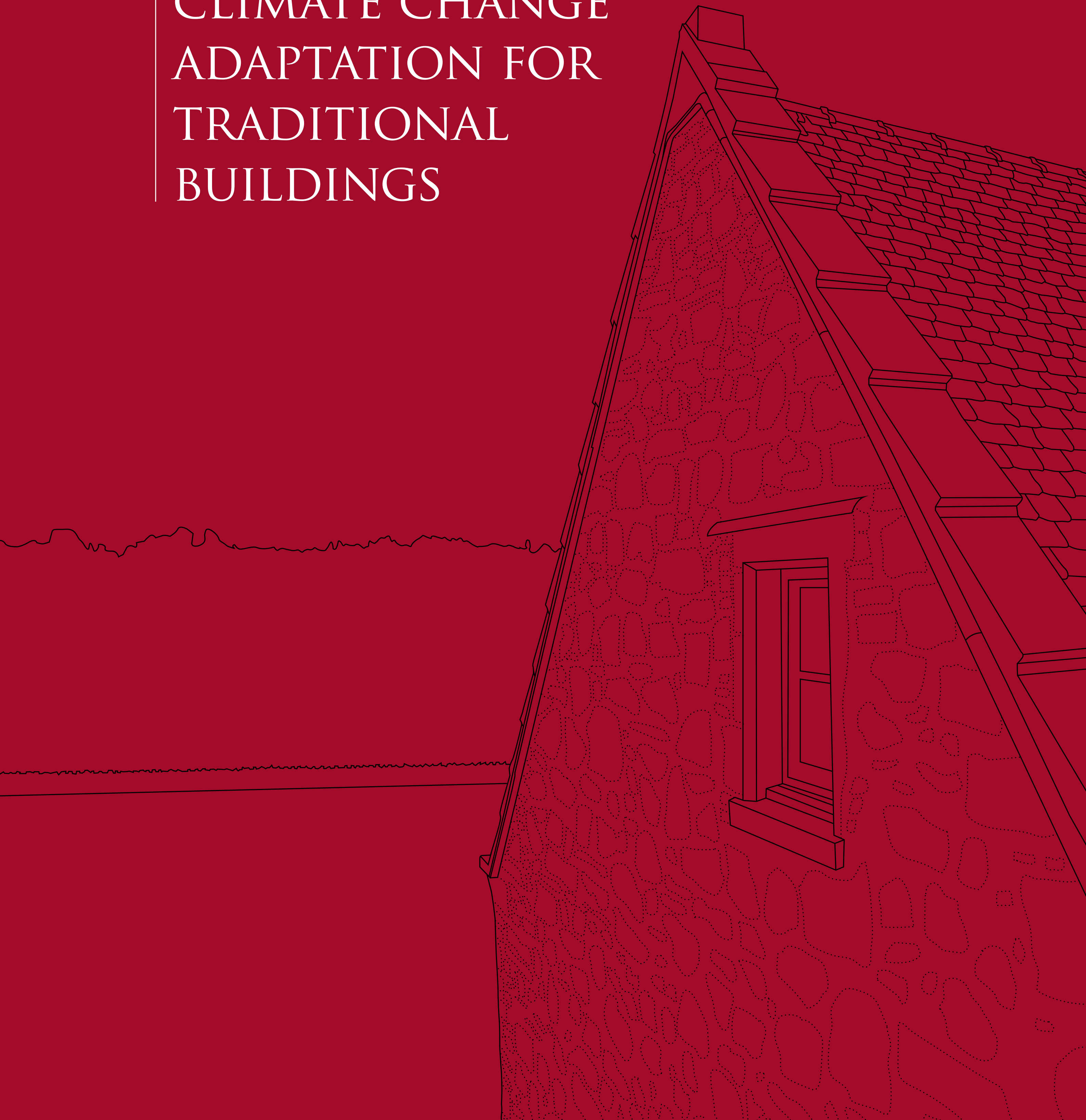
11

Short Guide

CLIMATE CHANGE ADAPTATION FOR TRADITIONAL BUILDINGS



HISTORIC ENVIRONMENT SCOTLAND
ÀRAINNEACHD EACHDRAIDHEIL ALBA

Adaptation Scotland
supporting climate change resilience

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Contents

1. Introduction

Scotland has always experienced severe weather, and most traditional buildings were designed and built sufficiently robustly to cope with the climate. However, some buildings that have functioned perfectly well for many years may become less able to cope with changing weather patterns caused by *climate change*. Often buildings have been poorly maintained or altered in such a way as to increase their vulnerability to severe weather. Maintenance and repair are the first steps in increasing resilience, but climate change presents new challenges, and some buildings may need to be adapted if they are to cope with the projected changes.

This Short Guide describes the key aspects of the external envelope of a traditional building that provide protection against the elements, and considers how these can be improved or adapted to increase a building's resilience to extreme weather events. It also considers the internal environment within older buildings, and how this can be managed to cope with changing environmental conditions. This guide is aimed at homeowners, building professionals and landlords wishing to maintain and improve the buildings in their care. A glossary of terminology is provided at the end of the guide.

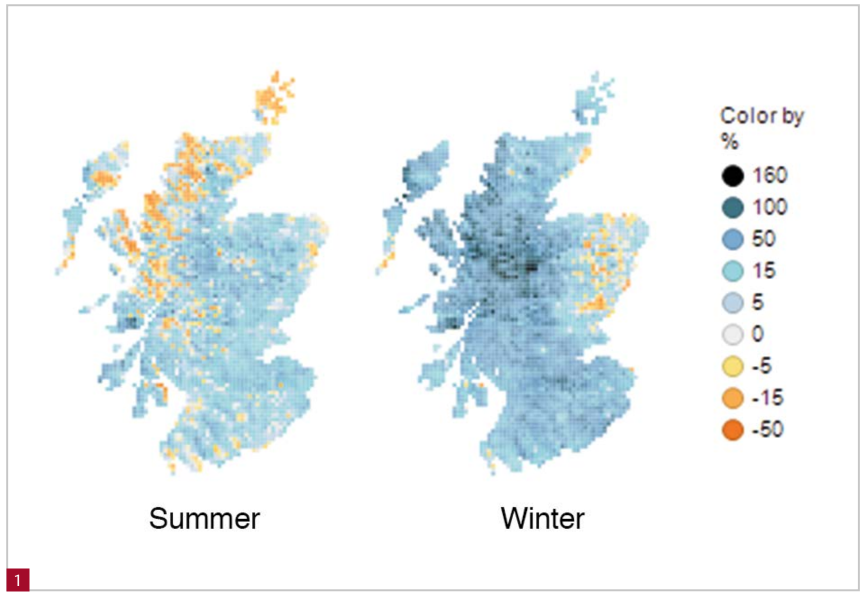


Fig. 1 Patterns of change in total precipitation (as a percentage) between 1961 and 2011 © SNIFFER 2014.

2. The impact of climate change on traditional buildings

2.1 Changes in weather patterns

The latter part of the last century has been characterised by overall warming with wetter winters, drier summers and increased frequency of extreme and unpredictable weather including heavy rain and storm events. Data gathered and analysed in Scotland's Climate Trends Handbook indicates that since the 1960s average *precipitation* has increased by 27 per cent, and in north and west Scotland winter precipitation has increased by over 70 per cent (Fig. 1)[i]. Sea level rise around the Scottish coast has accelerated in the last two decades and now exceeds 3-4 mm per year around most of Scotland.[ii]

Fig. 2 Buildings will be more at risk from extreme events such as flooding © Paul Hendy.

All the major models of global surface temperatures show a warming trend over the last century, with the ten warmest years on record since 1998. Evidence and analysis of the challenges presented by climate change are summarised in the 2012 UK Climate Change Risk Assessment Report.

Changes in climate are projected to continue and intensify through the present century, creating challenges for the built environment (Fig. 2). The potential effects of climate change on traditional buildings are summarised in Table 1.

i C. Barnett, J. Hossell, M. Perry, C. Procter and G. Hughes, *Patterns of climate change across Scotland: Technical Report*. SNIFFER Project CC03 (London: HMSO, UK Met Office, 2006).

ii A. F. Rennie and J. D. Hansom, "Sea level trend reversal: land uplift outpaced by sea level rise on Scotland's coast", Geomorphology 125 (2011): 193-202.

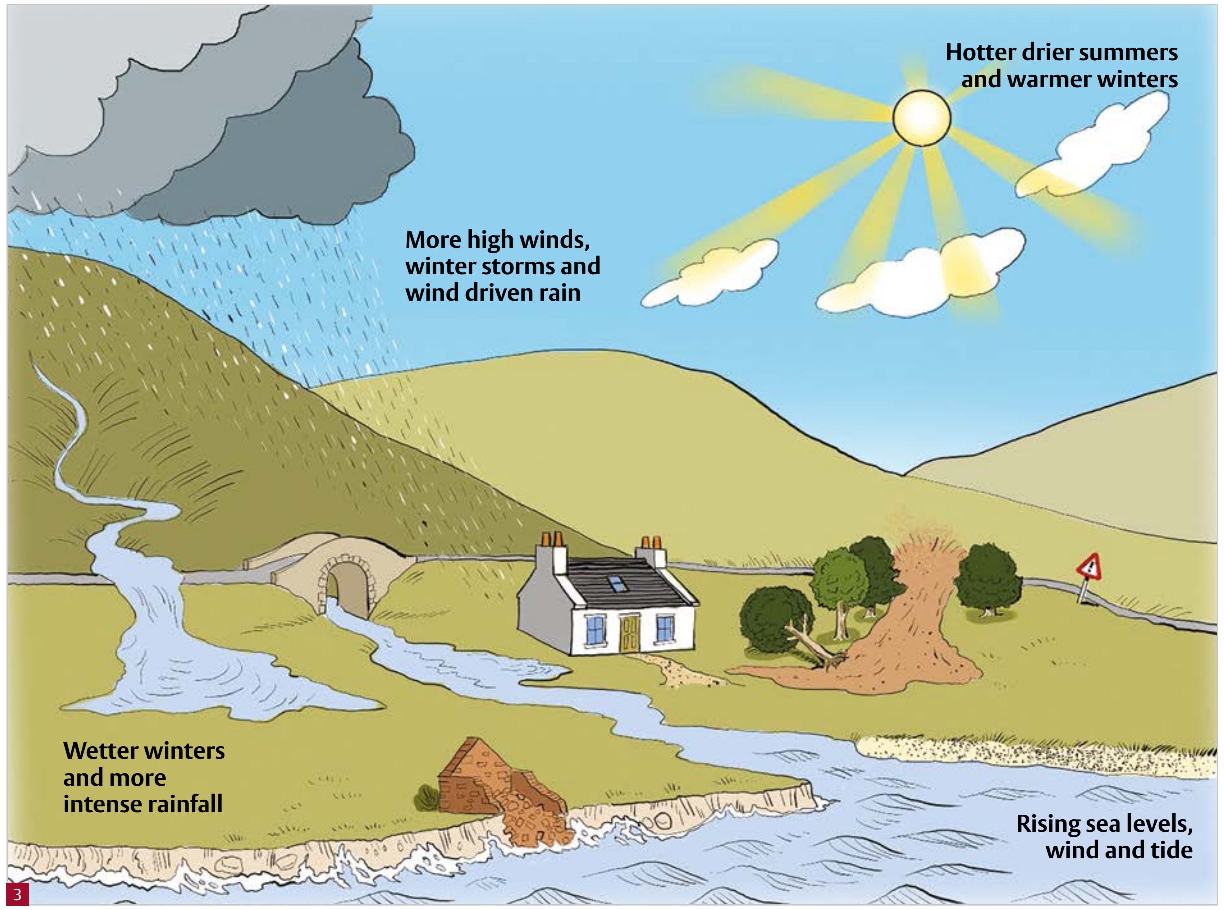
Climate change	Impact on buildings	Potential damage	Adaptation measures
Warmer winters	Higher internal humidity	Greater prevalence of insect pests and fungal attack Warping of timber elements	Improved ventilation
	Increased moss and algal growth	Staining and discolouration of masonry, dampness	Improved weathering detailing
Wetter winters	Rising ground water levels	Dampness in basements and wall footings	Enhanced drainage adjacent to buildings Improved water vapour handling on retaining walls
	Prolonged saturation of masonry	Algal growth, vegetation	Improved weathering details Repointing of masonry External coatings
Hotter, drier summers	Increased thermal stress on building fabric	Cracking of hard materials	Repair with flexible traditional materials such as lime mortars
	High internal temperatures	Thermal discomfort for occupants Warping/splitting of timber elements	Improved natural ventilation Install traditional blinds and/or canopies
	Ground shrinkage	Movement of foundations	Adapt surface drainage and landscaping/planting
More frequent, intense rainfall	Water penetration into fabric	Masonry decay and binder loss, rot and decay of internal woodwork, staining, reduced thermal efficiency	Improved weathering details More frequent maintenance Repair of mortar joints
	Blockage of gutters	Water overflows into/onto fabric	Increase size at critical points More frequent maintenance
	Splash back from hard surfaces	Wetting of adjacent masonry	Remove hard surfaces adjacent to walls Improve drainage around site
	Run off from adjacent areas	Flooding of under-floor or basements	Minimise hard landscaping Improve natural drainage of driveways and pavements
	Flash flooding from watercourses and roads	Physical damage; saturation of fabric. Damage from hasty clearing up. Sewage contamination	Attend to culverts and adjacent burns Routes for surge waterflows around buildings
Wind driven rain	Penetration of render/harling	Progressive wetting of walls	Better detailing
	Water penetration under roof covering	Roof leaks	Improved slating detailing Vapour open materials to disperse water
High winds/storms	Impact damage to fabric	Damage to slates/leadwork	Additional fastenings to ridges and slates Higher codes of lead Improved clips and raggle details
	Collapse of unstable masonry	Chimney damage	Maintenance of chimney fabric Improved haunching of chimney cans

Table 1: Table of common impacts to traditional buildings associated with climate change, showing potential damage and a summary of the adaptation measures given in this guide.

2.2 Risks for traditional buildings

Changing weather patterns are likely to result in a greater wind and water loading on structures of all types and in different locations (Fig. 3). Traditional buildings, in general those of solid wall construction built before 1919, are generally resilient, but can be vulnerable to greater stress if they have been altered or neglected. Where older structures have not been well maintained, extremes of wind and rain will accelerate the decay of worn or weakened elements resulting in gradual or sometimes catastrophic failure. Continued neglect can lead to structural movement and eventual failure; this is seen occasionally in the collapse of chimney stacks or the failure of large sections of masonry such as gable ends (Fig. 4). The maintenance of traditional and historic buildings is covered in Historic Scotland *Short Guide 9: Maintaining Your Home: A Guide for Homeowners*. Buildings in exposed locations (e.g. elevated sites, floodplains or coastal sites) are likely to be particularly at risk, even if they are in good condition.

Fig. 3 Illustration of climate change impacts on traditional buildings, as detailed in Table 1.



Alterations, such as hard landscaping close to buildings and development leading to loss of gardens, have inadvertently led to increased water run-off and splash back, resulting in high moisture levels in external walls or adjacent areas. Ground levels can become raised over time from natural deposition of organic materials or from poorly designed landscaping work (Fig. 5). Increased levels of water in the soil and impermeable materials next to buildings increase the risk of damp and associated problems. In some areas a rising water table or poor drainage will also have an impact on footings and foundations. Moisture from soils can contaminate porous masonry with damaging salts which can cause or accelerate stone decay.

Fig. 4 Water ingress has led to progressive failure of the chimney and masonry below.

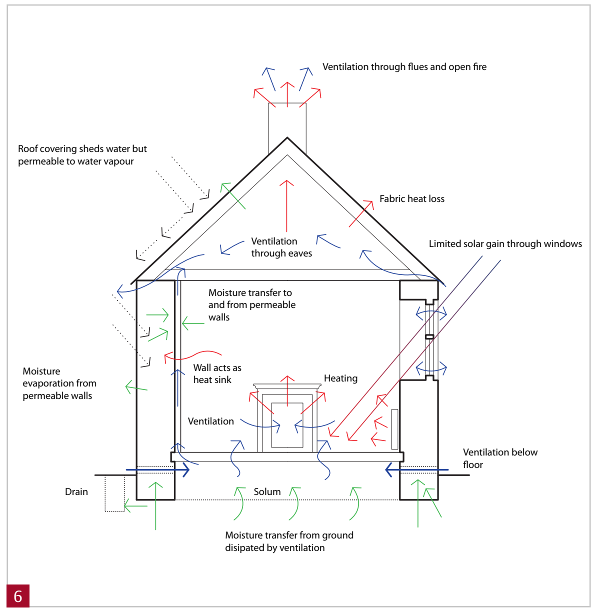
Fig. 5 Poorly designed hard landscaping close to building, partially obscuring the wall vent, inhibiting ventilation and concentrating moisture.

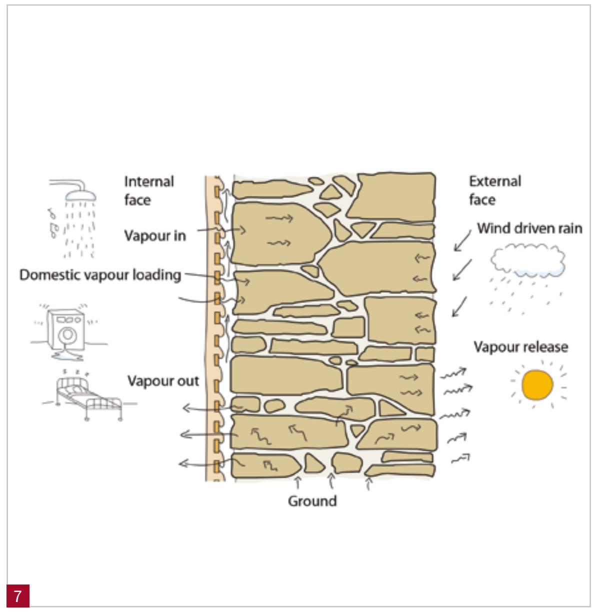
2.3 Water vapour movement and dispersal

The principles of *breathable construction*, using natural materials such as stone, lime and timber, have proved to be enduring and effective in traditional construction, provided the building is maintained. The ability of traditional buildings to allow water vapour transfer through the building envelope helps ensure the structure remains in a dry and stable condition and the internal environment is healthy for both the fabric and occupants (Fig. 6 and Fig. 7). However, when older buildings are subjected to high moisture loads, through persistent, heavy or driving rain, saturation of the masonry can occur. The use of incompatible materials such as cement renders and impervious paints, used externally or internally, can disrupt the necessary movement of moisture and further impede the drying process. Additional measures such as insulation with vapour barriers, blocking natural ventilation pathways and *tanking* can also hinder drying. Poor ventilation increases the risk of condensation, mould growth and timber decay.

Fig. 6 Transfer of air movement through the building envelope.

Fig. 7 Water vapour movement in a lime bonded mass wall.





2.4 Carbon reduction and energy efficiency

One important aspect of society's response to climate change is carbon reduction in housing. Older buildings, especially those built before 1919, are often seen as *hard to treat*, or even inherently unsustainable. In fact, many traditional buildings in Scotland, with substantial solid masonry walls, perform better than expected in terms of energy performance. With moderate adaptation they can be considerably improved to increase energy efficiency to acceptable levels (Fig. 8). Historic Scotland *Short Guide 1: Fabric Improvements for Energy Efficiency in Traditional Buildings* describes appropriate measures for improving energy efficiency in traditional buildings.

Fig. 8 This 19th century cottage in Fife has been fully insulated and upgraded, without loss of character or fabric.

2.5 Effects on the internal environment

Changing climatic conditions are likely to result in higher levels of moisture in the air. With this comes a greater risk of condensation, which can give rise to mould, timber decay and insect attack to structural timbers, internal finishes and furniture. Measures designed to save energy may in fact lead to overheating in some buildings. This is particularly likely in urban areas, where the concentration of heat caused by dense development, hard surfacing, mechanical servicing and poor ventilation can make buildings uncomfortable.

Energy efficiency measures may also inadvertently create unhealthy internal environments due to increased airtightness created by installing insulation, draught proofing or secondary glazing, fitting chimney balloons or blocking up chimneys and flues. Whilst such measures increase the thermal efficiency of a building, they also reduce the *passive ventilation*, which can result in poor indoor air quality. Increased air tightness is linked to elevated levels of CO_2 and other pollutants, particularly in bedrooms, and this can have a detrimental effect on the health and wellbeing of occupants.[iii]

iii T. Sharpe, *Occupier Influence on Indoor Air Quality in Dwellings* (Glasgow: MEARU, 2014).

2.6 Monuments and other structures

This document focuses on the effects of climate change on inhabited traditionally built and historic structures, but other structures and monuments will also be affected by changing weather patterns. This topic will be addressed in forthcoming Historic Environment Scotland publications, but similar principles apply, namely protecting the structure from saturation or extreme cycles of wetting and drying, management of water run-off, drainage and flood protection.

2.7 Effects on coastal areas

There is an increasing risk of coastal flooding from storm surges and, in some areas, land and buildings are under threat from coastal erosion and sea level rise.[iv] Adaptation in response to coastal erosion is beyond the scope of this document, but options that involve moving assets or accepting and recording loss need to be considered, as well as supporting natural defences. The most sustainable methods of adaptation should be adopted, and it may be that protecting land, buildings and archaeology from coastal erosion is not always possible in the longer term (Fig. 9).

Local Authorities and Marine Scotland are consenting authorities for certain operations in the coastal zone and as part of any planning considerations they consult with Historic Environment Scotland, the Scottish Environment Protection Agency (SEPA) and Scottish Natural Heritage (SNH). These agencies are working with the Scottish Government and other key partners to investigate past coastal changes and to anticipate future change.

Fig. 9 Coastal damage following extreme weather © Linda Flemming.

iv T. Ball, A. Werritty, R. W. Duck, A. Edwards, L. Booth and A. R. Black, *Coastal Flooding in Scotland: A Scoping Study*. SNIFFER Project FRM10 (Edinburgh: SNIFFER, 2008).

3. Maintaining and adapting the building fabric to increase resilience

3.1 Detailing for a changing climate

External details on traditional buildings such as *string courses*, *hood mouldings* and *cornices* exist primarily as functional elements to shed water and protect the building façade, although they can also be decorative (Fig. 10, Fig. 11 and Fig. 12). The rapid weathering and staining sometimes seen on buildings of modern design, often with flat roofs and unembellished *curtain wall* façades, illustrates the purpose of traditional detailing and the need to understand the micro-climate in which a building sits. Buildings which may perform well in a dry, southern European climate are typically poorly suited to Scottish weather conditions (Fig. 13).

Fig. 10 Cornices, string courses and projecting lintels all perform a protective function as well as being decorative.

Fig. 11 Hood mouldings help to shelter window openings from rain.

Fig. 12 Decorative detail on a 19th century property also performs a protective function.

Fig. 13 Poor detailing on a modern building in Edinburgh has led to staining of the masonry.

Regardless of architectural style, and allowing for local variations, traditional buildings in Scotland are generally composed of a limited range of materials and components, which were used in various forms from the late medieval to the end of the Victorian period. Plan forms tend to follow characteristic patterns, and the structure is typically composed of a pitched slate or tiled roof, solid masonry walls, timber windows, internal lime plaster linings and suspended timber or solid floors.

Detailing for weather protection and shedding water is long established in architecture and building practice, but has been superseded to some extent in modern construction by technological adaptations. Consequently the importance of detailing in the traditional built environment is often overlooked. The adoption and maintenance of robust detailing will be essential if Scotland's traditional buildings are going to be durable for the future. Maintaining good detailing alone may not be sufficient to handle current and expected changes in weather and climate (Fig. 14). Some innovative adaptation of traditional details, and the development of sympathetic new details suitable for traditional fabric may have to be considered.

Fig. 14 Heavy and sustained rainfall may overwhelm existing drainage.

The following sections consider traditional external building fabric and how elements can be best maintained, or in some cases improved or altered, in order to maximise their protective function. Some interventions may involve changes to the appearance of a structure, requiring planning or listed building consent.

3.2 Chimneys and flues

Chimneys

Chimneys are generally the most exposed element of a building, and by their nature are typically hard to access; consequently they are often neglected (Fig. 15). Not only are chimneys exposed to wind and rain, but flue gasses and combustion products deposited within the masonry from decades of solid fuel fires can accelerate the decay of stonework, particularly if the flues are no longer in use. *Mortar* joints can wash out over time or degrade, allowing water to penetrate the fabric and encourage vegetation, all of which can compromise structural integrity. In order to protect the chimney stack from water run-off and penetration through the chimney cope, additional lead detailing may be required (Fig. 16).

Fig. 15 A poorly maintained chimney stack.

Fig. 16 A well maintained chimney with lead installed beneath cope stones.

Climate change adaptation for traditional buildings
3. Maintaining and adapting the building fabric to increase resilience

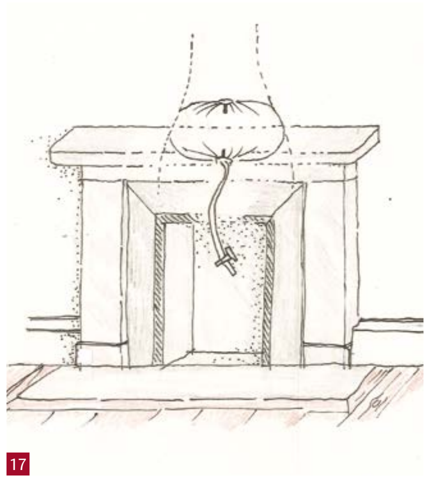
Flues

Since the Clean Air Acts of the mid-20th century, and the almost universal adoption of central heating in homes, the use of open fires is now rare. Many flues and chimneys are unused and sometimes blocked up and capped, and the fireplace closed up. Historically, most buildings would have had fires burning on a regular basis, and the warm air drawn up from the fire would keep the flue and surrounding masonry dry, helping to prevent deterioration.

The wider fabric of the building, particularly in gable walls, benefited from the warming and drying effect of the open fires or stoves. Since many gable walls now have disused flues, penetrating damp and associated problems are likely to be more prevalent, and will increase as winters become wetter. Flues that are no longer in use should be kept obstructed with a vented *cowl* on the chimney can, and some degree of ventilation at hearth-level. The use of chimney balloons (Fig. 17) or hearth boards (Fig. 18) will allow the flue to be closed off in response to external conditions such as high winds or cold weather, while in urban areas where overheating is likely to become a problem, open hearths and ventilated flues can assist in providing passive ventilation in summer.

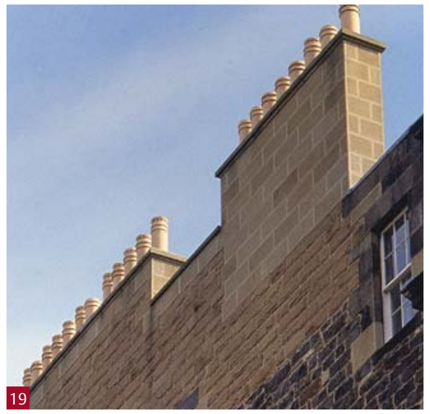
Fig. 17 Chimney balloon used to close a flue.

Fig. 18 A hearth board used to close a hearth when the fire is not in use.



Reconstructions

In some cases, a chimney may need to be taken down and rebuilt. If the stone is in good condition, it can be reused and any new stone carefully matched to the existing (Fig. 19). Ceramic flue liners will make construction easier and will increase the durability of the re-built chimney. The chimney cope should normally be of natural stone, possibly composed of two or three sections if weight for handling is a consideration. The opportunity should be taken, where appropriate, to modify or improve the detailing on the chimney stack, *haunching* and junctions to allow adequate shedding of water. This should include a correct drip mould detail under the outer edge of the cope. If this is not present or is damaged such a detail can be incorporated into any new work. Alternatively, a drip detail can be formed with the use of a lead strip set into the cope edge (Fig. 20), or for a more complete cover a lead apron can be formed around the chimney cans to the edge of the cope.



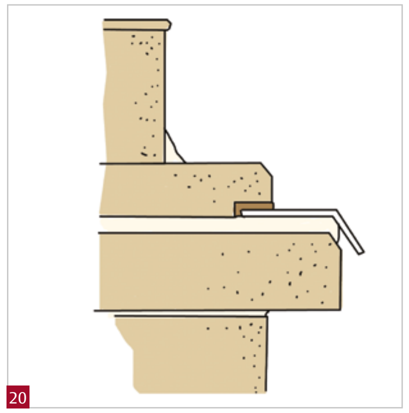


Fig. 19 Repaired chimney using matching stone and good detailing. Note reinstated drip mould details to copes, and lead flashing to protect vulnerable areas of original stone.

Fig. 20 Drip detail using lead strip for traditional chimney copes.

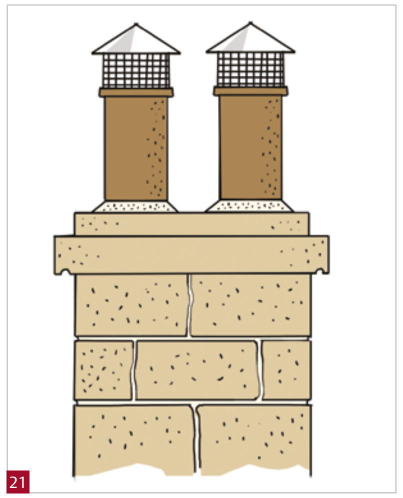
In Scotland flues are normally terminated with a ceramic chimney can or pot in a variety of architectural forms. Chimney cans should be haunched in a weak cement mortar. A zinc plated cowl, chinese bonnet (Fig. 21) or ceramic 'elephant's foot' should be fitted to keep the rain out, with a grille to prevent bird access.

At the base of the chimney where it meets the gable end, there is a sometimes a string course running across the gable wall that connects the two *skew copes*. This forms an edge or drip at the base of the chimney and throws water clear of the gable wall (Fig. 22). This detail will prevent saturation and excess weathering of the central part of the gable end (Fig. 23). Where it is damaged or has been removed, replacement of the string course should be considered. Lead flashing can also be dressed over an existing detail. Where weathering details are not present, redesigning the chimney to include them may be appropriate if the chimney is being rebuilt or repaired. Such methods have a visual impact, which can be significant, and where a building is listed such adaptations may require listed building consent.

Fig. 21 Traditional chimney detail with a metal grilled cowl or 'chinese bonnet.' Note drip mould detail under the outer edge of the cope.

Fig. 22 String course at the base of a chimney.

Fig. 23 Heavy water loading on a gable.



Wood burning stoves

Wood burning or multi-fuel stoves are increasingly popular, especially in rural areas, for the heating of houses. The stove provides effective ventilation, the flue is kept warm, and low level heat is dissipated throughout the building, benefitting the occupants and the building fabric. A wood burning stove does however require a reliable source of dry and seasoned wood, which can be expensive. Wood burning stoves are not always suitable for urban areas, where air quality restrictions apply. Very little adaptation is normally required for the installation of a wood burning stove, but commonly the flue will need to be lined, and an inspection and smoke test will always be required to ensure that the chimney is functioning correctly and providing sufficient draw. Further information on larger *biomass* and other renewable energy systems is available in Historic Scotland *Short Guide 8: Micro-renewables in the Historic Environment*.

3.3 Roofs

Roof coverings

In Scotland the majority of roof coverings on traditional buildings are slates, plain clay tiles or *pantiles*. In particularly exposed areas and in high winds there is a tendency for water to be blown up under the slates, even where they are correctly laid. To address this issue the use of an underlay might be necessary to ensure the roof remains watertight during bad weather. To prevent excessive movement or rattling of slates in high winds, slates can be secured with additional nails to the sides, known as *cheek nailing*, every third or sixth course (Fig. 24). On turrets and exposed areas cheek nailing is sometimes necessary for every course. In some parts of Scotland where larger slates are used they are fastened with two nails on each slate, in the English way. In this case additional nailing is not normally required.

Fig. 24 Fixing slates with additional fastenings to prevent wind lift.

With pantiles there is little variation possible in fitting or overlap; however, they tend to be more open to ventilation and subject to wind lift, especially at the *eaves*. This may be the reason for the narrow courses of slates at eaves level (called an *easing course*) which is a common feature of pantiled roofs in Scotland. In some locations lime mortar is used to close gaps in a pantiled roof (Fig. 25). The addition of lime mortar torching or bedding might be necessary where wind driven rain or wind lift is causing problems.

Fig. 25 Mortar torching on pantiles to prevent wind lift.

Verges and edges

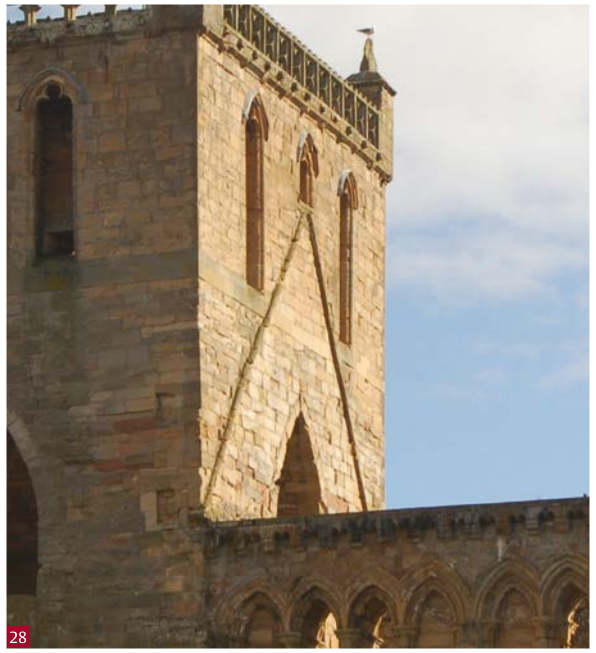
Where the roof junction with the gable (the *verge*) is flush, with no overhang, the edge slate is cut with an angle on the edge corner, to drive water onto the middle of the next slate, away from the junction (Fig. 26). This minimises run off onto the gable wall, reducing the chances of saturation and accelerated weathering. Sometimes the verge is secured with a cement *fillet*, but where exposure is more extreme, a zinc or lead ridge roll can be fixed onto the verge (Fig. 27) to give better protection against damage from wind lift and prevent wind driven rain reaching the *sarking* and roof timbers behind.

Fig. 26 Edge of slate cut to drive water away from the junction and minimise run off onto the gable.

Fig. 27 A zinc verge on a traditional slated roof.

Roof junctions or abutments

Where the slate or other roof elements join the masonry of a wall or chimney, sometimes called an *abutment*, the junction is usually formed with a lead skew. This area can be a point of weakness for water penetration. In early buildings substantial *raggles* were often formed, with a stone hood to cover the edge of the slates, giving enhanced protection (Fig. 28). Such a detail is effective and can be appropriate for certain building types where improvements are required.



Later buildings do not normally incorporate an inbuilt stone at the abutment, but rely on a formed mortar or lead skew. The junction is typically finished with a weak cement mortar and a lead soaker underneath. On a traditional roof the slate is also slightly raised at the skews to minimise water flow at the vulnerable junction, and encourage water to run inwards over the slated area (Fig. 29). As precipitation increases this detailing is likely to become more important, and should be retained wherever roof repairs are carried out. It should also be designed into re-roofing specifications where appropriate.

Fig. 28 Evidence of robust abutment detail at the junction of the nave and the tower at Jedburgh Abbey.

Fig. 29 Skew with mortar filet. Note the raised slates at the junction to encourage water to run inwards away from the junction.

Watergates

Where large volumes of water flow across roof edges, an additional feature called a *watergate* or a *secret gutter* is sometimes necessary, instead of a mortar skew detail. This typically consists of a lead trough formed at the eaves of the roof and raggled into the skew or abutment (Fig. 30 and Fig. 31). Slates or tiles are dressed up to and partially over the channel. Forming a secret gutter will require re-dressing of slates and forming new leadwork. It is a fairly standard detail, but carries an increased cost and has a visual impact. The durability of this upgrade may make it worthwhile in the longer term.

Fig. 30 Where volumes of water are high, a secret gutter can be formed with lead.

Fig. 31 A watergate formed with lead to improve rainwater disposal.

Storm rolls

Where water flow at certain points is very high, the use of a *storm roll*, formed from lead dressed over a wooden roll, can be used to ensure deflection of water into the rhone or gutter. While sometimes necessary, they can be visually intrusive, and adoption of this detail must be considered carefully, particularly on prominent roofscapes (Fig. 32).

Fig. 32 Enhanced lead detailing, such as the use of a storm roll, can be conspicuous, but is an effective way to improve rainwater disposal in areas of high water flow.

Skew copes

The stone slabs that are generally used to cover gable end wallheads are often vulnerable to water ingress. The joints between the stone copes should be narrow, less than 5mm, and therefore need a fine ashlar-type pointing. Historically there have been various ways of forming these junctions: plain butt joints, stepped joints with an overlap, or a raised mould on the upper cope to shed water to the sides (Fig. 33). While requiring additional stonecutting work, such weathering details are particularly applicable today, as increasing rainfall and wind driven rain puts a strain on exposed areas.

Climate change adaptation for traditional buildings
3. Maintaining and adapting the building fabric to increase resilience

Fig. 33 Raised moulding on upper skew copes to ensure effective water run-off and prevent water ingress.

The width of a skew cope is also important, to give a degree of overhang from the wall plane; some architectural styles handle this with a well formed drip detail on the wall side (Fig. 34). In some cases these overhangs are inadequate and additional detailing may be required to protect the gable (Fig. 35).

Fig. 34 A good margin and drip detail on a stone cope to shed water.

Fig. 35 New lead drip detail under replacement skew copes.

As skew copes face high levels of exposure, yet are hard to access, defects can go unnoticed and left unattended for considerable periods, often until they become critical. Neglect of these roofing details can lead to progressive saturation of the gable end, resulting in damage to interiors as well as a reduction in the thermal performance of the building. Lack of maintenance in these areas is likely to lead to more substantial and costly repairs being required at a later stage.

In some cases defective skew copes can be re-bedded onto a lead damp proof course (DPC), to provide extra protection against water ingress (Fig. 36). If this approach is taken, the copes will need to be secured in place by additional fixings, to avoid slippage. The edges of the DPC should extend out from the gable wall by about two inches as a drip detail to shed water clear of the wall.

Fig. 36 Bedding of a skew cope with a lead DPC underneath.

Where the skew copes have failed badly or the existing detailing is insufficient to adequately protect the roof, supplementary weather protection can be provided using lead sheet. This is a fairly drastic measure and will have a significant visual impact, as well as being expensive. In some circumstances the lead junction with the skew cope is formed on the upper side of the skew, with a raggle cut into the top. This detail is sometimes described as *half-cloaking* and gives additional protection, but is visually distinctive (Fig. 37). Where the skew is fully cloaked in lead, the results are even more striking (Fig. 38). However, such adaptation may be appropriate in situations where other repairs are not possible, or there is a desire to retain existing (historic) material which is no longer performing satisfactorily. Fastenings and detailing must be sufficient to prevent wind lift and the sheet lengths configured to prevent thermal creep and cracking. The effect on the appearance of the gables should also be considered. If the building is listed, alterations may need listed building consent.

Fig. 37 Half cloaked skew cope giving additional protection.

Fig. 38 Here the entire skew has been cloaked in lead.

Climate change adaptation for traditional buildings
3. Maintaining and adapting the building fabric to increase resilience

An additional detail on a flat stone cope at eaves level is the formation of a small channel, approximately 5 mm deep, that runs at 45 degrees across the lower skew cope towards the slate side (Fig. 39). This traditional detail is seldom seen in new work, but for a small amount of additional labour it ensures that water from the surface of the cope is directed onto the slates, preventing staining and progressive saturation of the *skew putt* and the adjacent gable masonry and mortar.

On some Scottish buildings a feature called a skew putt was developed to direct water away from the corner. A variety of decorative forms of this functional detail evolved, for both secular (Fig. 40) and ecclesiastical buildings (Fig. 41).

Fig. 39 Small channel detail on a skew cope to keep water off the corner.

Fig. 40 A traditional Scottish skew putt from the 18th century.

Fig. 41 A skew putt on a 19th century church.

Crow steps

A traditional Scottish variant of the skew cope is a *crow stepped* or *corbie stepped* gable. This is a distinctive architectural feature with a functional purpose, providing a windproof edge detail, and historically may have facilitated chimney access. However, with this detail there is also an increased area of exposed masonry. Exposed areas of masonry commonly require periodic re-bedding or re-pointing, with an appropriate detail on the roof side to form the junction with the slates; often a mortar skew. Due to the distinctive form of a crow stepped gable, and the narrow band of masonry adjacent to the slates, a secret gutter or watergate is hard to fit in and not always appropriate for a roof of this type. An important detail to minimise staining and accelerated wear on the gable elevation is to form a slight *wash* (a slope at approximately 5 degrees) on the horizontal surface of each crow step, ensuring water runs off on the slated side. Using lead sheet to provide additional protection to crow stepped gables can have visually striking results (Fig. 42).

Fig. 42 Lead cloaking to crow step gables can alter the appearance of the building.

If the gable is rendered, traditional practice was to form a smooth or feathered junction with the render and the crow steps or other stone dressings. Masonry features were generally *limewashed* to form a breathable but water resistant surface. This gives additional protection to the masonry, helping to prevent saturation and facilitating water run-off. Limewashed buildings require periodic maintenance, which incurs a cost and disruption. However the reinstatement of a *harled* and limewashed finish, particularly for gable ends, can be one option in increasing the resilience of vulnerable areas against increased driving rain. This finish can be particularly effective where additives are used with a hot-mixed limewash to provide a water resistant coating.

Decorative detailing

In parts of Scotland where high precipitation has been an issue for a long time, local architectural styles developed in response to the conditions. Additional detailing was often incorporated in a decorative way and adapted to prevailing fashions. Details might include oversailing eaves (Fig. 43) and extended verges on gables, often finished with decorative barge boards (Fig. 44). If significant works to the roof are being planned, increasing the protection to the underlying walls by the addition of such details may be an option, where it is compatible with the overall design and appearance of the building.

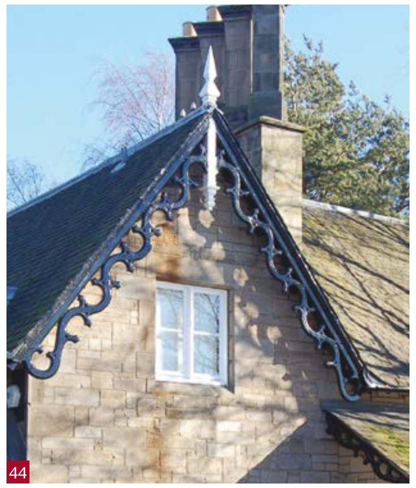


Fig. 43 Oversailing eaves to protect gable.

Fig. 44 Projecting eaves finished with decorative bargeboards.

Valleys

The meeting point of two roof pitches usually consists of a lead valley. On large roofs the high volume of water run-off during heavy rain can give rise to water flowing at high speed along the valley. If water overflows at the point where the valley joins the rhone it will run down the wall below and saturate the masonry. Where the valley gutter is unable to cope with the water volume, additional lead can be used to raise a baffle at the junction.

3.4 Rainwater disposal

Rhones

Generally in Scotland rainwater is collected from the edge of the roof, at the eaves, into rhones or gutters. These carry the water into vertical downpipes. This system forms the roof drainage, with components being referred to generally as *rainwater goods*. Rhones are set at a shallow angle to give a run which allows the water to move along at a suitable rate. Over time the run or height of the rhone can become distorted, causing water to back up or overflow (Fig. 45). Poor detailing can also cause rhones to discharge onto the masonry, leading to persistent damp problems. Increased water flow can cause movement of debris, leading to blockages. Warmer temperatures and wetter winters may result in increased vegetation growth (e.g. moss on roofs, overhanging trees etc.) with potential to block rainwater goods. Regular inspection and cleaning, at least twice a year, is required to keep rainwater goods in working order. In some circumstances a larger width rhone may need to be installed. Rhones normally route water into the downpipes through a small spigot, sometimes called a *drop*, into the downpipe. However, in some cases the drop flows into a cast iron or lead *hopperhead*. The outlets for these can be undersized and may need adaptation.

Fig. 45 Overflowing rhones in an area of high water flow.

Downpipes

The roof water is taken down the building clear of the wall by the downpipes. Most downpipes on traditional buildings are made of cast iron, although zinc and lead are also found. These elements are prone to overflow, due to blockage, damage or lack of capacity (Fig. 46). A blocked downpipe may not pose an immediate threat to the building fabric, but overflow causing repeated wetting and progressive saturation of the adjacent masonry will result in significant problems over time. Blocked, defective or leaking downpipes should be repaired promptly and certainly within a few weeks. To mitigate the effects of a blockage, the downpipe should terminate into a gulley trap with an open angled shoe (Fig. 47).

This will prevent a blockage below ground causing water to back up. Where lengths of downpipe are joined at the *faucet* or socket between lengths, these joints should be left unsealed, or dry to allow backed up water to escape (Fig. 48).

Fig. 46 Vegetation growth around downpipe due to lack of maintenance.

Fig. 47 A gulley trap provides the connection between the downpipe and the drains.

Fig. 48 Downpipe junctions should remain unsealed in order to allow backed up water to escape.

In some cases modern repair works have resulted in rainwater goods, particularly downpipes, being installed which have a smaller diameter than the original. This can occasionally be seen very obviously where the downpipe passes through the string course (Fig. 49). Inadequately sized rainwater goods often result in blockages and overflow. On some elevations additional downpipes may be needed, especially where there are turns and corners that make the run of the rhone shallow. Where this is not possible, replacement of the downpipes with those of a similar pattern but larger diameter may be required. Complex roof drainage arrangements may not be able to cope with intense rainfall.

Fig. 49 Works to this building have neglected to reuse the original stone rainwater bracket, resulting in an overly complex arrangement.

Parapet gutters

Some architectural styles, particularly more formal buildings of the 18th and 19th centuries, conceal roof drainage behind parapets, to create an uninterrupted façade. While architecturally this is very elegant, the practice requires more complex drainage designs which can be prone to blockage, and difficult to access for maintenance and repair. The increasing intensity of precipitation means that debris (e.g. leaves and twigs) is more easily carried down roof pitches and along gutters, with potential to create a blockage.

While many parapets have overflow spouts, parapet gutters are always over wallheads and therefore any overspill leads inevitably to water penetration into the masonry below (Fig. 50). While traditional building fabric can cope with a certain degree of occasional wetting and drying, frequent saturation and water flow into a building from such a drainage failure can result in damage to internal finishes and contents. Extended saturation can lead to staining, algal growth and the decay of stone and timber elements, while the leaching out of binders from the masonry can cause progressive weakening of the structure.

Fig. 50 Staining and decay of masonry resulting from a blocked parapet gutter.

The proper functioning of a parapet gutter is essential. The capacity of the main drain must be sufficient and, in the event of a blockage, the diameter and detailing of the overflow should be sufficient to throw water away from the elevation, not merely allowing it to run down the face of the masonry. Water stains or salt staining below parapet overflows are a quick way to identify blockages in the system. Overflow spouts from parapets are for the temporary relief of blockages or to provide additional surge capacity only; not as a primary water disposal measure.

In some buildings with parapet gutters, surface water from the roof is routed to the back of the building through a pipe in the attic space. Such arrangements are vulnerable to blockage and often hard to access for cleaning and repair. A shallow gradient can encourage the progressive build-up of deposits, ultimately leading to blockages. In addition, many early pipes were formed from lead and are frequently damaged by foot traffic in the roof space.

Snow boards

In some locations, especially on street frontages where buildings were directly above the pavement, *snow boards* were commonly fitted to the lower part of a slated pitch (Fig. 51). These were to prevent the slippage of snow from a sloping roof pitch overloading and damaging the gutters or causing injury to passers-by. Recent extremes of winter weather have highlighted the practicality of snow boards in some areas. Consideration should be given to their retention or fitting on street elevations, especially over doors and vennels. Snow boards are traditionally made up of a length of durable timber, normally a redwood or hardwood, mounted on angled steel brackets set into the slates and fastened onto the sarking boards below. Snow boards are not appropriate for all buildings, but where they form part of the regional vernacular detailing they may be a suitable addition. Advice should be sought from the local authority about consent if a building is listed or in a conservation area.

Fig. 51 Standard pattern snow boards, fitted above a street elevation.

3.5 External walls

Gables

Gable ends of buildings, especially in exposed locations, are particularly vulnerable to driving rain. Where walls have been exposed to a long period of saturation or penetrating damp, the lime component of the mortar (the binder) can be progressively dissolved and washed out, resulting in a weakened wall core. This means the two outer skins of the wall will no longer be properly tied together, with the potential for structural deformation or even collapse (Fig. 52).

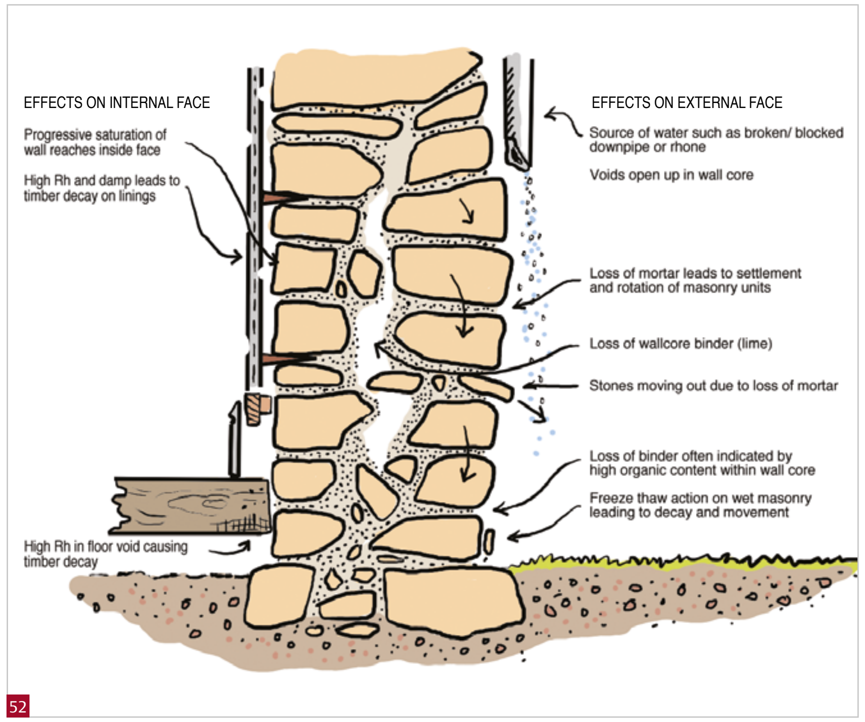


Fig. 52 Diagram showing a cross section of a weakened mass wall.

Climate change adaptation for traditional buildings
3. Maintaining and adapting the building fabric to increase resilience

Dampness in gable walls is most commonly due to a combination of defects in the chimney, the skews, the masonry pointing and frequently blocked rhones and downpipes. Often cement pointing or renders can exacerbate the problem as cement can be vulnerable to cracking and crazing, allowing water to be drawn in and become trapped (Fig. 53). Chimney flues within the masonry of gables can be prone to decay due to weather damage from the outside and corrosive flue gases on the inside, both accelerated by the presence of moisture. Thus the masonry is being attacked both externally and internally, with greater potential for problems arising.

Fig. 53 A lack of protective water shedding detailing has led to staining, and progressive crazing of this cement-rendered gable.

Repair of weakened walls

The repair of damaged or saturated walls requires correct detailing and protection of the walls, re-pointing and in some cases re-grouting or re-lining of flues. Re-lining flues with poured cement, while effective in addressing the structural integrity, can sometimes make damp problems worse. This is because fine cracks in the lining may allow capillary draw of wind driven rain into the flue, which can result in water-borne migration of salts and tar into adjacent masonry; often coming through into the internal plaster finishes. Where flues have to be relined, there is often little choice but to re-build the chimney lining, using traditional masonry techniques, preferably from the outside. The use of ceramic flue liners may be appropriate, bearing in mind that open fires need a wider diameter flue than wood burning stoves.

Parapets and cornices

At the highest part of a building, parapets are one of the most exposed elements. In the wet climate of Scotland these features were not just aesthetic architectural details; they also helped shed water from the top of a building. Keeping the upper part of a wall free of standing water is necessary to keep masonry dry, and the detailing or shape of the parapet, with its associated cornice, cills and string courses below, is key to this as it ensures that water is thrown clear of the façade at all levels (Fig. 54).

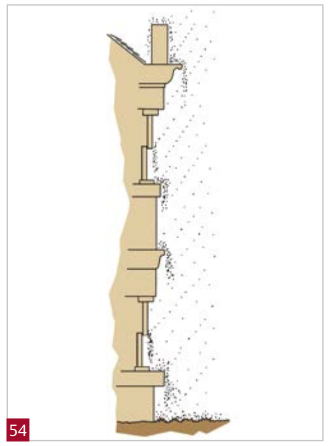


Fig. 54 The relationship between parapets, cornices and the weather.

Fig. 55 Render repairs to the parapet of an early 20th century building in the west of Scotland; the lack of detailing makes the masonry prone to saturation.

The function of a cornice in certain buildings is especially important; normally set at high level just below the parapet, it ensures that water from precipitation is directed away from the building, and falls some way down the elevation before coming into contact with the wall. The detailing on the cornice can be similar to that found on chimney copes, with a clearly formed drip mould on the underside.

Some early 20th century buildings feature parapets with no protective drip detailing. This invariably causes problems in all but the most sheltered locations (Fig. 55). The absence of such details may be acceptable for buildings in areas with low rainfall, but is ill-suited to most parts of Scotland.

In areas of high exposure, the remodelling of parapet or cornice details may be required to ensure the protection of the masonry below if on-going long term damage is to be avoided; this can often be done with the careful use of sheet lead or zinc (Fig. 56). Such alterations will affect the appearance of the building, and will need careful consideration to minimise the visual impact (Fig. 57).

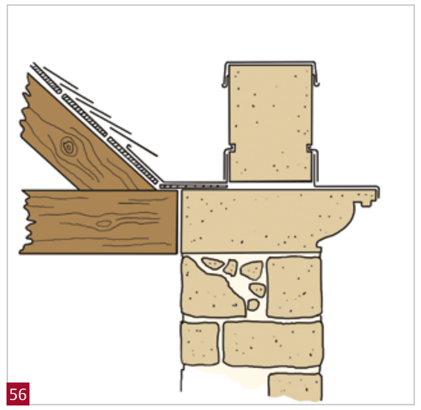


Fig. 56 Indicative details for a parapet and associated cornice, including sheet led and drip moulds.

Fig. 57 Even the careful use of lead will have visual effects.

Lead sheet is a good material for the protection of parapets and copes, as it can be easily dressed over profiled stone, and is extremely durable. Lead is useful in the upgrade of building details that may have been sufficient for the prevailing conditions when built, but which are now either degraded or simply not coping with the increased rainfall of today's climate. Using lead sheet in this way (cloaking) involves dressing lead sheet over the existing masonry detail, forming an edge angled to shed water clear.

Often the importance of the details on parapets and cornices is not appreciated; sometimes they are thought to be purely decorative and in a misguided attempt to save money on repair work they are poorly repaired, allowed to decay or even removed (Fig. 58). In addition to the architectural damage, there is a technical penalty as well; the upper parts of a wall become wetter and consequent internal and external defects can develop.

Fig. 58 A traditional masonry elevation where the cornice has been removed.

High quality masonry cornices will generally have the masonry cut so that there is a run (sometimes called a *wash*) away from the building, allowing the water to run off. In some cases the masonry joint with the parapet will be around 10 mm higher than the upper surface of the cornice (Fig. 59). The mortar in the joints between the lengths of the parapet stones should be protected by a raised margin on the *arris*. This is a detail which is both decorative and functional, and can be seen on many classically designed buildings throughout Europe.

Fig. 59 A raised margin on a parapet to minimise water loading on the mortar joint.

Masonry parapets and cornices without such subtle detailing are not necessarily inadequate, but they will be more vulnerable to weathering of the mortar joints, leading to water ingress (Fig. 60). Careful attention to maintenance and appropriately specified ashlar repointing where necessary will adequately manage this risk.

Fig. 60 Internal decorative damage, indicating defects on the external cornice.

Works to parapets and cornices should include the repair, reinstatement or introduction of new drip moulds and associated details to ensure water run-off (Fig. 61). Specialist repair mortars may be suitable in small areas of masonry damage, as they can be moulded and dressed to match the existing material, and are sufficiently durable (Fig. 62). For larger defects a new stone indent will be required (Fig. 63).

Fig. 61 Zinc protection to cornice and parapet below a repaired chimney.

Fig. 62 An eroded cornice detail repaired with a restoration mortar.

Fig. 63 Missing section of cornice awaiting replacement with a new section of masonry.

Hood mouldings

Windows and doorways are vulnerable areas, as water run-off is driven onto the window pane, and below onto the cill and underlying masonry. Over time, where detailing is poor, this excessive wetting can result in damage to window joinery, or water ingress around the window frame. Some architectural styles incorporate masonry hood mouldings which are both decorative and functional, with the practical benefit of directing water away from the window and cills (Fig. 64). On exposed elevations consideration may be given to the addition of an angled hood moulding, formed from a timber frame finished with lead. While their use in Scotland has mainly been for architectural effect (Fig. 65), they may be specified for managing water on elevations in some situations.

Fig. 64 Stone hood mouldings on a former school house © P. Beaton.

Fig. 65 Decorative timber hood moulding, painted to match the stonework on an early 19th century elevation in Edinburgh.

String courses

On many Scottish buildings there are stone string courses set at each floor level on principal elevations. While these may be part of the architectural decoration and integral to the style of the building, string courses, like parapets, cornices, and plinths at ground level, have a protective function, as they help direct water away from the façade of the building (Fig. 66). Over time the string course detail may become eroded or is sometimes deliberately removed, allowing water to run unimpeded down the walls. Where string courses have been damaged or lost, new masonry can be indented, or the existing string course can be improved by the addition of a lead cloak and drip detail.

Fig. 66 A 19th century string course.

Cill details

Shedding water from the window cill is an important aspect of keeping the underlying wall fabric dry, as well as reducing the water loading on any window openings further down. Exposed elevations with many windows are particularly vulnerable to heavy wetting of the masonry. The water run-off from the windows can leach though the masonry immediately below the window cill, where it may be thinner than in the main wall, giving rise to internal damp problems and damage to linings and finishes. Consequently, window cills often extend proud of the wall, providing a drip in order to throw water clear of the structure (Fig. 67).

67

Fig. 67 Water being shed from a projecting window cill.

In some cases the addition of a drip detail on the underside of the cill edge should be considered, particularly where the cill is flush, the elevation is exposed, or where there is an ongoing water ingress problem. A drip can be formed by fitting a strip of lead into the bedding mortar of the cill (Fig. 68), or by cutting and bedding a new stone cill with an integral drip detail. The upper surface of cills should be formed with an adequate angle to aid water run-off.

68

Fig. 68 New drip detail on a 19th century cill.

External harling and renders

Even well maintained masonry walls with good detailing may need additional protection from driving rain. This was understood in traditional construction, and rubble masonry was commonly protected by a layer of lime harling and a finishing coat of limewash. Thicknesses vary, from a thin *sneck harl* or *slaister point* to thicker layers made up of several coats. Changing fashions during the 19th century led to a decline in this practice, and in some cases external harling was (and sometimes still is) deliberately removed to expose the rubble stone beneath. Rubble work, by its nature, consists of a higher proportion of exposed joints, and was often used on side or rear elevations, or buildings of lower status, which were then protected by a lime harl or limewash (Fig. 69).

Climate change adaptation for traditional buildings
3. Maintaining and adapting the building fabric to increase resilience

69

Fig. 69 Traces of original render on the gable end of a late 18th century building in Stirling.

Modern renders, often applied later, tend to be cement based and not suitable for traditional masonry construction as they are usually too hard, inflexible and impermeable. The use of cement renders can lead to moisture becoming trapped within mass masonry walls, contributing to stone decay and internal damp problems. Traditional lime harling, by contrast, is well suited to provide the additional protection needed against wind driven rain. The relatively flexible nature of lime harling reduces the incidence of hairline cracking, while the open pore structure allows water vapour dispersal and prevents the build-up of moisture in a masonry wall.

Reinstatement of external lime coatings has proven to be effective in managing the effects of wind driven rain even in exposed locations in Orkney and Shetland (Fig. 70). In one case the removal of a cement render from a building and its replacement with lime pointing and a limewash has prevented running water on the inside face of the building. The effect on the appearance of the building can be significant, but this should be considered alongside the significant benefits in the condition of the fabric, and the comfort and health of the occupants.

70

Fig. 70 The condition of this exposed 18th century building in Shetland was significantly improved by the use of a lime harl and lime wash.

Limewashing

Historically harling of any thickness was normally finished by several coats of limewash. The limewash consolidated the completed harling, giving a water-resistant finish and filling any cracks, providing protection from wind driven rain and splashes at ground level (Fig. 71). Additives can be incorporated to improve the qualities of the limewash, for example to increase water resistance or durability. These can include linseed oil, tallow, casein, or proprietary products developed for the same purpose. Even dressed masonry elements on harled elevations were often limewashed, although there is a more recent fashion for leaving such features exposed. The use of lime wash can assist in the conservation and consolidation of weathered decorative or sculptural masonry.

Fig. 71 Limewashing of masonry elevations consolidates the masonry units and the mortar.

Waterproofing

Where external coatings have been lost or are defective, a solution sometimes proposed is the application of waterproof coatings. Such barriers are typically formulated from silicon based resins, cementitious or bituminous materials and may be trowel applied or sprayed on. Some waterproof masonry paints also offer the same qualities. Some of these are described as microporous or breathable but most offer insufficient *vapour permeability*. Whilst waterproofing barrier products may relieve the symptoms of penetrating damp for a short period, they are unlikely to offer a long term solution. The application of impermeable coatings can lead to damage to stone and brickwork, as they can cause moisture to become trapped within the body of the wall, and prevent diffusion of internal moisture through the walls. Once applied, most proprietary coatings are very difficult to remove, and may begin to peel and degrade over time. External barrier coatings are not recommended for use on traditional buildings; limewash or mineral paints are normally a more suitable solution. These materials are considered in more detail in Historic Scotland *Short Guide 6: Lime Mortars in Traditional Buildings*.

External cladding

Where walls, particularly gables, are exposed to extreme weather conditions, for example in coastal or highly exposed areas, masonry is sometimes protected by external cladding, normally consisting of slates, tiles or weatherboarding fixed to timber battens (Fig. 72). This is not a common detail in Scotland, but there are some good examples. Where an external wall is particularly vulnerable, and existing detailing is failing to protect the building, the addition of external cladding, appropriately detailed, may be a suitable adaptation option in some circumstances. Such an alteration will change the appearance of the building, and planning permission or listed building consent is likely to be required.

Fig. 72 External timber cladding to a building in the Scottish Borders.

Basement and ground floors

As rainfall levels increase, solid ground floors may be vulnerable to wetting from raised water tables, water run-off from adjacent areas or splash back of water onto the building from hard landscaping. Drainage to a property should be adequately managed to ensure that water is effectively dispersed away from the structure, for example through the formation of gullies or drainage pipes below ground. All water from roofs should be directed well away from the building. Where soil and other materials have built up against basement walls, moisture and salts can penetrate and lead to problems inside the building. The use of de-icing salts during the winter months can lead to masonry decay; this is exacerbated where salts build up adjacent to buildings, and where poor drainage and splash back allow the soluble salts to come into contact with masonry at low level. Raised ground levels should be lowered, especially if they are obstructing air vents or bridging a damp proof course. Existing pipes and services may need to be rerouted. Where levels cannot be lowered, a layer of water resistant clay sheeting (supplied in preformed rolls) can be mounted against the external face of the wall to prevent the ingress of liquid water into the wall. Reopening of previously blocked air vents will also help.

Modern waterproofing techniques, for example *tanking* with bituminous or plastic material, seek to address the ingress of water by sealing the inside surface of the wall. This can be effective in achieving a dry interior, but may simply be trapping the moisture in the structure. Such methods do not address the source of the water ingress or prevent saturation of the masonry. Deterioration of masonry may continue as saturated masonry is more prone to frost damage, leaching of mortar joints or degradation from salts. In addition, excess moisture may simply be relocated to another part of the structure.

In areas of minor moisture ingress, the correct use of internal lime plaster, applied directly onto the existing masonry and finished with a breathable coating such as lime wash or a clay paint, may be sufficient to allow water vapour or small amounts of penetrating moisture to be dispersed. This may result in some staining or discolouration to internal finishes as the wall dries out, necessitating periodic redecorating, but it does not necessarily indicate a serious defect (Fig. 73). Modern 'stain blocking' or mould resistant paints can inhibit the passage of moisture and should not be used in areas of high moisture load.

73

Fig. 73 Lime plaster finish used in a basement.

3.6 Openings

Porches and canopies

Some architectural designs, particularly for Victorian and Edwardian houses, incorporate a porch or canopy at the entrance. These are commonly timber constructions of varying design and complexity which provide a protective shelter over the doorway to keep the wind and rain out of the main house, and shelter for callers during bad weather.

Porches are normally fully enclosed, but sometimes a basic canopy or portico was formed, with a pitched, slated roof or lead covered flat roof or pediment (Fig. 74). In the 19th century such adornments were part of the architectural language of the building in addition to their practical function. Their reinstatement or creation can give an additional level of protection to the building and to users and (if enclosed) can help improve energy efficiency. The addition of porches or canopies will not always be appropriate however, and will generally require consent if the building is listed or in a conservation area.

74

Fig. 74 A decorative porch canopy from the late 19th century.

Sometimes quite modest adjustments to building elevations can make a difference to the resilience of vulnerable areas. For example, the addition of a simple hood to the lintel over a flush mounted door can help keep rain off the timber door, preventing its wetting and consequent decay (Fig. 75).

75

Fig. 75 The addition of a small hood over this flush mounted storeroom door has kept water off the top of the frame and the door.

Storm doors

Street entrances, especially in urban districts, were often protected by a double leafed storm door, giving access to a small internal draught lobby (Fig. 76). While partially for security, they also provide an effective form of draught control and reduce heat loss during entry and exit. Storm doors were typically double-leaved with flat profiles, giving good protection against the elements, especially driving rain. The storm doors sometimes folded back neatly into the recess to appear as panelling when opened.

In larger properties a substantial panelled external door gave access to an internal porch or lobby, separated from the rest of the house by a glazed door. During fine weather the external door would remain open, letting in light and ventilation, while in bad weather and at night the outer door would be shut to give protection from the elements (Fig. 77). Reinstatement of or improvements to external doors, such as draught-proofing, can help improve energy efficiency and weather resistance.

Fig. 76 A traditional storm door © P. Beaton.

Fig. 77 In fine weather the outer door can be left open, for light and ventilation.

Common stairs

Whilst many traditional properties will have separate porches, halls or storm doors, many tenement buildings only have a single door for the occupants to access from the street. This means that the stairwell is often cold and draughty in winter. When refurbishing a traditional tenement, it is worth considering the addition of an internal glazed door, set back from the main entrance to provide a draught lobby. This reduces air infiltration and noise to the common stair, and heat loss from the flats adjacent to the common areas. Where decorative internal elements are affected, such alterations need to be carefully detailed. Advice should be sought from the local authority if the building is listed.

Storm glazing

External *storm glazing* is not a traditional feature in Scotland, but in many parts of Europe and North America it is common practice to install external secondary glazing during the winter months. Externally demountable storm glazing gives protection to the window fabric from driving rain and draughts, and increases the energy efficiency of buildings by minimising heat loss through the window panes and around the frames (Fig. 78). Storm glazing is generally removed during the spring and summer, to allow full ventilation. If appropriately and sensitively designed, it may be an option for some traditional buildings as a more robust alternative to secondary or double glazing.

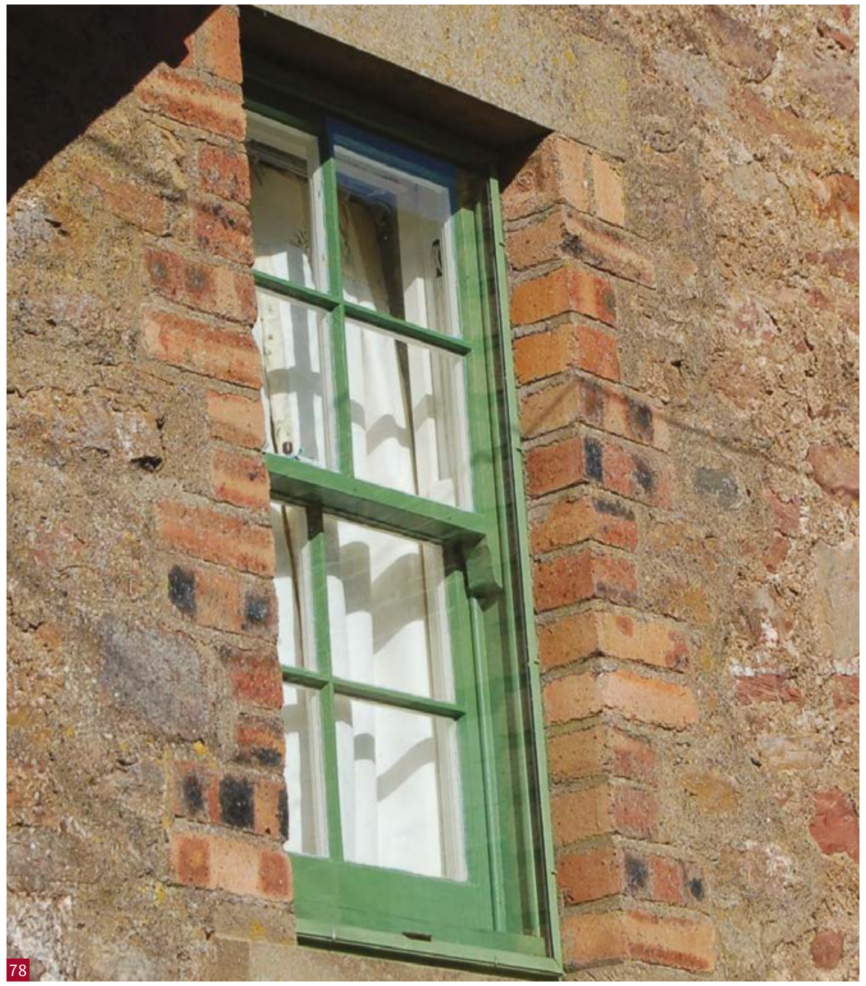


Fig. 78 Storm type external secondary glazing providing weather protection to a traditional window.

Weather-stripping

Windows and doors can be weather-stripped with minimal effect on fabric to reduce draughts and keep out wind driven rain. Draught-stripping is often carried out for energy efficiency, to reduce heat loss from gaps around sash and case windows and external doors, but weather-stripping also has an important role to play in keeping wind and water out of buildings. Traditional windows and doors can be weather-stripped by cutting a narrow rebate into the edge of the stile, and fitting in a strip of brushes, vinyl, rubber or polyurethane foam. Doors can also be weather-stripped at the threshold, to prevent wind and rain being driven in at floor level.

4. Internal environmental modifications

Heating and cooling

Most adaptation of buildings in relation to climate change has focused on reducing greenhouse gas emissions through energy efficiency improvements. As well as improving the efficiency of boilers and heating systems, the emphasis is usually on upgrading the building fabric by insulating and draught-proofing. Details on how to upgrade traditional buildings for energy efficiency are covered in Historic Scotland *Short Guide 1: Fabric Improvements for Energy Efficiency in Traditional Buildings*.

Passive ventilation

The properties of passive cooling and ventilation inherent in many traditional buildings are commonly overlooked in refurbishment projects in favour of mechanical systems, yet the latter require more maintenance and energy to operate. The high thermal mass of traditional masonry structures means that they are generally good at buffering temperatures during periods of overheating. Where possible, consideration should be given to the re-instatement of passive measures in traditional buildings. This includes ensuring that ventilation grilles are not blocked, chimney flues are kept open and chimney balloons removed or deflated during the summer months. In many cases passive ventilation features were common in domestic buildings such as tenement stairwells, where modest ventilation through small vents in the apex of the lightwell kept condensation down and ensured a degree of fresh air to otherwise unventilated areas (Fig. 79).


79

Fig. 79 A discreetly placed vent at the apex of a lightwell in an Edinburgh tenement stair.

Larger non-domestic traditional structures such as schools used passive stack ventilation to draw air through the building. Often this would terminate in a decorated ventilator called a *fleche* (Fig. 80). Recognition of the function of such features has largely died out, but such low cost passive features should be kept operational before modern mechanical equivalents are introduced.


80


81

Fig. 80 A fleche, or ventilator, on a 19th century school building.

Fig. 81 Traditional roller blinds can reduce solar glare in hot weather and help retain heat in low temperatures and at night.

Sash and case windows

Sash windows should be kept in good working order, with both top and bottom sashes openable, allowing effective air circulation and low level background ventilation (superseded in modern windows by *trickle ventilation)*. The warmer air leaves via the open top sash, and fresh cooler air is drawn in through the open lower section.

Shutters and blinds

In many properties with traditional windows, shutters are set into the window reveals. These can often be re-instated or introduced with minimal disruption (see Historic Scotland Inform Guide on *Timber Window Shutters*). Their use allows control of sunlight to prevent overheating in the summer, and management of draughts and cold in the winter. Roller blinds (Fig. 81) help reduce solar gain and glare, reducing the need for mechanised cooling. They also reduce heat loss and improve thermal comfort.

Indoor air quality

Potentially negative consequences of energy efficiency upgrade works to the fabric of a building are not always considered, particularly when a building is made more air tight. Energy improvements without adequate ventilation provision can increase the risk of condensation, and also increase the levels of carbon dioxide and contaminants, leading to poor air quality. Maintaining indoor air quality in refurbished buildings requires raising awareness and educating people about their homes, so that occupants initiate regular purge ventilation and maintain trickle ventilation. Bedroom doors should be kept open or ajar during the night, while chimneys and air vents should be kept open and unobstructed.

5. Maintaining and adapting areas adjacent to buildings

5.1 Surface drainage

Gulley traps and soakaways

Roof drainage will take rainwater down to ground level, but must be directed clear of the wall footings and the immediate adjacent area to a *soakaway* or a common drainage system (Fig. 82). Failure to take surface and roof water away from a building will result in progressive saturation of the masonry at ground level. Downpipes should route water into a grille-covered gulley trap which prevents the ingress of debris and sediment into the below ground drainage system, and also allows easy maintenance.


82

Fig. 82 A temporary but sensible solution to cope with blocked below ground drainage.

French drains

Where ground has become waterlogged around a building, causing dampness in the external walls, one solution may be to install a French drain. A French drain consists of a trench with a perforated pipe laid on gravel and backfilled with gravel or coarse stone. They are sometimes installed close to buildings or elsewhere on sites where drainage is poor or the water table is high. Care must be taken not to undermine or destabilise the foundations of the buildings, which in very old properties may not be substantial. Improving or maintaining existing roof and below ground drainage should be the priority before the installation of a French drain is considered, but where existing drainage is inadequate, they can be an effective adaptation to cope with high levels of water in the soil close to buildings.

Rainwater harvesting

Traditional buildings can often be fairly simply adapted to harvest rainwater from run-off. Rainwater can be recycled to flush toilets or stored for garden use; it reduces the use of treated, potable water for such purposes and eases the loading of waste water on drainage systems. The simplest method of rainwater harvesting is using a water butt, which is connected to a downpipe (Fig. 83). Zinc downpipes can be fitted with proprietary attachments which allow water to be channelled into a container. Altering a cast iron downpipe can be tricky, and involves making an opening in the downpipe to which an attachment is fixed, directing run-off into the water butt. Alternatively, a section of downpipe at the base can be removed, allowing water to feed directly into a water butt. This will require a suitable overflow and drainage system. More complex systems of rainwater harvesting involve collecting, pumping and storing water so that it can be used for internal *grey water* systems.


83


84

Fig. 83 Water butt connected to downpipe.

Fig. 84 Distortion of window and masonry due to subsidence exacerbated by poor drainage.

Sustainable drainage systems

While soft, permeable surfaces such as lawns or grass verges allow water to drain away naturally through the soil, most drainage systems channel collected water through a piped system to a watercourse. During periods of heavy rain these can become overloaded, leading to localised flooding. Conventional piped systems can also lead to pollution of watercourses from run-off of silt or pollutants from agricultural, urban or industrial sites.

Sustainable water management systems can be incorporated on or around a site or into the wider landscape of existing buildings to help manage water run-off and protect watercourses. These include permeable surfaces or filter strips which are incorporated into hard or soft landscaping, filter and infiltration trenches or *swales* (low tracts of land or ditches which slow water run-off and allow water to be dispersed) and the creation of wetlands or ponds. Such measures, often called *SUDS (Sustainable Urban Drainage Systems)* are now commonly incorporated into new developments. Similar systems have historically been in place in the traditional built environment, particularly the existence of permeable surfaces and ditches to manage water run-off. The creation or reinstatement of such systems can be an important part in managing drainage.

Subsidence and heave

Leaks in below ground pipes can result in saturation of the adjacent ground and washing out of small particles of the soil (known as *fines*) from beneath the building. The consequent reduction in soil volume can sometimes result in subsidence leading to distortion of the elevation (Fig. 84). This is especially noticeable on projecting elements such as stairwell turrets or the corners of buildings. Below ground drainage should be checked with rods, and the use of a cable mounted CCTV probe should be considered where defects are suspected.

Heave, from water-logged clay soils, may become a problem in certain areas of Scotland as incidences of heavy rainfall increase. Heave can also occur if large trees are removed or there are other changes in ground conditions. Expansion and shrinkage of soils can cause damage to foundations and cause structural damage to buildings. Where there is any doubt about movement in buildings, the advice of a structural engineer should be sought.

5.2 Local and regional effects

Flooding

Shifting weather patterns, changing land management and the increase in hard surfacing around domestic properties can all increase the risk of flooding. Traditionally constructed buildings are no more vulnerable to the effects of flooding than other buildings, and in some respects they have more natural resilience to water damage than modern structures built using composite materials. The Historic Scotland Inform Guide on *Flood Damage to Traditional Buildings* provides more information on this subject.

Commonly flooding occurs after heavy and sustained rainfall when the ground becomes saturated. This can be compounded if rivers burst their banks, overloaded local drainage systems back up and overflow, or where run-off is focused in built-up areas. A blocked culvert in one locality may lead to road drainage being overwhelmed and water moving into nearby gardens and the backs of properties (Fig. 85).

Fig. 85 An urban drainage feature vulnerable to blockage and flooding.

Climate change adaptation for traditional buildings
5. Maintaining and adapting areas adjacent to buildings

Replacing traditional elements such as timber doors or floorboards with waterproof alternatives is generally not advisable for traditional buildings. Such an approach is likely to result in a considerable loss of original materials and features and can actually make drying out more difficult if flooding does occur. Where there is a risk of future flooding it may be advisable to consider some anticipatory adaptation, such as adding demountable flood barriers for openings (Fig. 86).

Fig. 86 Temporary barriers can be fitted over openings in flood-risk areas © Paul Hendy.

Water-resistant coatings which seal up the external envelope and help retard the penetration of water through the building envelope are not generally recommended. They are often bituminous or tarry in formulation and are extremely difficult to remove once applied to brickwork or stone; they also tend to be unsightly. Tanking of walls and basements can sometimes lead to their full-scale failure in a severe flood due to the high pressure exerted on the walls. Similarly, impervious paint finishes, applied membranes and cement based renders should be avoided as they can inhibit the escape of trapped water and slow the drying process (Fig. 87).

Fig. 87 Blistering external paint due to trapped moisture behind.

Buildings close to the sea

Buildings close to the sea are often exposed to extremes of weather, and are vulnerable to salt spray, which can be carried inland by high winds. Increased levels of salt in stone masonry can result in accelerated decay and the increased absorption of moisture from the air in humid conditions. Where buildings are vulnerable to salt spray and frequent saturation, maintaining the mortar joints appropriately, normally using a suitably specified lime based mortar, is an important element in protecting the building against the effects of climate change.

Salt spray is particularly deleterious to iron and steel components, causing accelerated corrosion to unprotected metal. Features such as railings, rhones and downpipes are vulnerable. Exposed metal work should be frequently checked for defective paintwork and corrosion (Fig. 88). Maintenance is essential and re-painting at least every five years or so is likely to be necessary. Where ironwork is in poor condition it may need to be stripped back, cleaned and re-coated.

88

Fig. 88 Example of poor repair and corrosion of iron railings.

Older structures were sometimes constructed with iron cramps in the masonry to hold stones together. Open joints, cracks or defects in the stone allowing water to penetrate can lead to corrosion of embedded iron (Fig. 89), causing further cracking and spalling of the masonry. Maintenance of the stonework is an important preventative measure, but where porous stonework is allowing water penetration, the cramps may need to be removed and the stone repaired using indents. The application of water resistant external coatings is not recommended.

89

Fig. 89 Open joints in masonry have allowed water to penetrate, leading to corrosion of embedded iron cramps and fracturing of stone.

Climate change impacts are also affecting the topography of the foreshore in some areas, including its physical make-up and its stability. In some cases adaptation and maintenance works to a building may be insufficient if the adjacent area is being eroded or disrupted (Fig. 90). Coastal protection measures are beyond the scope of this document. However, a wider view of the asset and its future may have to be considered, including recording and abandonment, if climate change impacts are severe.

90

Fig. 90 Coastal erosion at Tantallon Castle, North Berwick.

6. Consents and permissions

Although the majority of traditional buildings do not have statutory protection, some are listed or within a conservation area, and some are scheduled monuments. In such cases consent may be required for alterations to the buildings including changes to the roof, windows or masonry, the addition or removal of external coatings and the addition of rainwater goods or porches. It is advisable to speak to the local authority or Historic Environment Scotland at an early stage to discuss where consents may be required and to come to agreement about what would be most suitable where adaptations are being considered.

Listed Building Consent

Listed Building Consent must be obtained where proposals will alter the character of a listed building. This applies regardless of the category of listing (A, B or C) and to work affecting both the interior and exterior. The planning authority (in most cases the local council) will advise whether work is likely to affect the character of a listed building and will therefore require consent. All applications for consent are made through the local planning authority.

Scheduled Monument Consent

If a monument is scheduled, the prior written consent of Historic Environment Scotland is required for most works, including repairs, and certainly for alterations. This is called Scheduled Monument Consent. Normally works should be the minimum necessary, consistent with the preservation of the monument. If your building is scheduled then you should speak to Historic Environment Scotland at an early stage to discuss repairs or alterations. Churches that are in ecclesiastical use are not scheduled, although monuments attached to them may be.

Planning Permission

Planning Permission may be required for alterations or additions to a building, particularly where buildings are in a conservation area or in multiple ownership. The local planning authority will advise whether permission is required and what is likely to be granted consent.

Ecclesiastical Exemption

Buildings that are in use as places of worship do not require listed building consent, except for total demolition. There is a voluntary scheme for listed building control for work to the exterior of places of worship belonging to some denominations. This allows a local authority, often with guidance from Historic Environment Scotland, to make recommendations, while leaving the final decision to the Diocese. This scheme would cover alterations to the roof, rainwater goods or external fabric. Several church denominations have Decision Making Bodies (DMBs) which have responsibility for regulating alterations to churches. Where changes are being considered to churches for adaptation or increased resilience, the planning authority should be consulted in the first instance. Planning permission is not covered by Ecclesiastical Exemption and may still be required for some works.

7. Conclusion

Scotland has always had to contend with extreme weather conditions, and buildings have generally been designed to cope with the climate. However, the changing climate in Scotland will add additional pressures such as increased rainfall, particularly in northern and western areas, and more driving rain and flooding. Extreme weather events will always damage the most vulnerable parts of a building first, especially areas that have not been properly maintained. Whilst the measures by which traditional buildings can be made more resilient to weather and exposure are often not new, the understanding of the purpose of certain building details may have been forgotten, and the need for regular maintenance and appropriate repair is often overlooked. Many traditional buildings in Scotland can be resilient to extreme weather events without requiring any modifications. However, in some cases, adaptation will be required if the structure is to continue to perform its function over time and for maintenance to remain affordable. Reinstatement of original features or the adoption of enhanced or additional detailing can go a long way in protecting a property from weather damage, saving money and protecting the value of an investment as well as conserving the traditionally built environment.

8. Contacts

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Historic Environment Scotland
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Adaptation Scotland
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E: adaptationscotland@sniffer.org.uk
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The Scottish Flood Forum
Caledonian Exchange, 19A Canning Street, Edinburgh, EH3 8HE
T : 01698 839021
W: www.scottishfloodforum.org

The Scottish Environment Protection Agency (SEPA)
Clearwater House, Heriot Watt Research Park, Avenue North,
Riccarton, Edinburgh, EH14 4AP
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9. Further Reading

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10. Historic Environment Scotland technical conservation publication series

The following publications are all free to download and are available from the publications page on our website: www.historic-scotland.gov.uk/conservation

Technical Papers

Our Technical Papers series disseminates the results of research carried out or commissioned by Historic Environment Scotland, mostly related to improving energy efficiency in traditional buildings. This series covers topics such as thermal performance of traditional windows, U-values and traditional buildings, keeping warm in a cool house, and slim-profile double-glazing.

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 Environment Scotland and the results are part of the evidence base that informs our technical guidance. This series covers measures such as upgrades to windows, walls and roof spaces in a range of traditional building types such as tenements, cottages and public buildings.

INFORM Guides

Our INFORM Guides provide short introductions to a range of topics relating to traditional skills and materials, building defects and the conservation and repair of traditional buildings. This series covers 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.

Short Guides

Our Short Guides are more in-depth guides, aimed at practitioners and professionals, but may also be of interest to contractors, home owners and students. The series provides advice on a range of topics relating to traditional buildings and skills.

11. Glossary

Abutment	Where the slate or other roof elements join the masonry of a wall or chimney.
Arris	A sharp edge formed by the meeting of two flat or curved surfaces.
Biomass	Organic matter used as fuel, commonly wood in pellet or chip form.
Breathable construction	An informal term which describes the ease with which moisture vapour can pass through a material (see vapour permeability).
Cheek nailing	Nailing the sides (or 'cheeks') of a slate to the sarking, in addition to the slate head (top).
Climate change	A change in regional or global climate patterns, largely attributed to increased levels of atmospheric carbon dioxide.
Cloaking	Lead sheet applied over masonry to prevent water ingress to stonework.
Cope	Masonry or concrete slab projecting over a masonry element, designed to shed water.
Cornice	Projecting line of masonry, often at the top of an elevation, designed to finish the elevation at the top and to route water away from the building.
Cowl	A conical or hood-shaped covering, fitted to a chimney pot to maintain the draw whilst preventing water ingress.
Crow-step/corbie step	A stepped masonry arrangement at the head of a gable leading to a chimney stack or gablehead.
Easing course	The initial three or four courses of slate at the eaves on an otherwise pantiled roof.
Eaves	The lower parts of a roof which project beyond the face of the external walls.
Faucet	The flange on a downpipe, allowing connection with the one above.
Fines	Small particles of soil.
Fleche	A small spire on the roof ridge, normally of timber, lead or cast iron and often acting as a ventilator.
Hard to treat	An informal term used to describe a property that cannot be easily thermally improved using low-cost measures (e.g. cavity wall insulation) due to the age of the structure, the nature of its construction or nature of occupancy.
Grey water	The waste water from baths, sinks, washing machines and other kitchen appliances.
Harl	Scottish form of roughcast in which the mixture of the aggregate (small even-sized pebbles) and binding material (traditionally sand and lime) is cast onto a masonry wall. In traditional harls the aggregate is within the mix (wet dash), in non-traditional 20th century harls the aggregate is dashed on separately (dry dash).
Haunching	The use of mortar to bed chimney cans or other roof details.
Heat island effect	An urban environment, consistently warmer than its rural surroundings due to increased use of plant, absorption and retention of heat from buildings, roads and hard standing.
Heave	Upward movement of the ground beneath a building, resulting from soil expansion.
Hood moulding	Projecting moulding over an arch or lintel, designed to throw water off an underlying opening or other feature.
Hopper/ drop	A container at the top of a downpipe receiving water from rhones or gutters.
Limewash	A simple type of traditional breathable paint or coating made from lime and water, with or without additives.
Mortar	A material which can be worked or placed in a pliable state, and becomes hard when in place, used for bedding or pointing brick and stone in a wall. It is formed of a binder, aggregate and enough water to make it workable.
Mortar torching	A coating of mortar applied to the underside of tiles or slates to prevent wind lift.
Pantile	Fired clay roofing tile which is s-shaped in section, fitted to overlap its neighbour.
Passive ventilation	The natural, unobstructed movement of air through a building, via features such as windows, flues and vents.
Precipitation	Rain, snow, hail or sleet.
Raggle	Groove cut into masonry, often to receive the edge of a roof covering or glass.
Sarking	A continuous layer of timber boards fixed horizontally across the rafters, onto which slates or tiles are laid.
Secret gutter	A narrow lead tray used to form an abutment where the sloping edge of a roof abuts a wall.
Skew	The junction between a roof and masonry at gable ends.
Skew copes	Flat stone slabs, or copes, generally used to cover gable end wallheads.
Skewputt	A stone so shaped that it supports the skew copes built higher and at an angle to it.
Slaister point	A style of pointing with lime or cement that fills the joints and recessed areas of adjacent stone, sometimes called 'flush pointing'.
Sneck harl	Roughcast applied to the joints in a wall to cover snecks but leave the face stones exposed.
Snowboards	Boards or wire netting in wooden frames, fitted to prevent large volumes of snow slipping off the roof or blocking rainwater goods. By retaining the snow, they allow it to melt safely.
Soakaway	A pit filled with rubble or hardcore, through which waste water drains slowly into the surrounding ground.
Storm glazing	External demountable secondary glazing used during the winter months to give protection to the window fabric from driving rain and draughts.
Storm roll	Lead dressed over a wooden roll, used to ensure deflection of water into the rhone or gutter.
String course	A continuous band of stone or brick running horizontally around a building designed to shed water from the elevation.
SUDS (Sustainable Urban Drainage Systems)	A natural approach to managing drainage in and around properties and other developments, designed to drain surface water in a manner more sustainable than routing run-off through a pipe directly to a watercourse.
Swale	Ditches or low tracts of land which slow water run-off and allow it to be dispersed.
Tanking	A method of waterproofing porous basements to prevent moisture entering, using a bituminous coating or membrane.
Trickle ventilation	A small opening in the building envelope to allow continuous natural ventilation in spaces.
Vapour permeability	The ability of a material to allow water vapour to pass through it. Sometimes called 'permiance'.
Verge	The junction between the roof and the gable.
Watergate	A channel, typically lead-lined, running between the masonry and the roofing material.

Climate change adaptation for traditional buildings
11. Glossary