



TECHNICAL PAPER 29

REVIEW OF HOT-MIXED EXTERNAL LIME
COATINGS IN SCOTLAND 1997-2016



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Cover image: Monimail Tower in Fife, with a traditional hand-cast hot-mixed lime mortar harl applied in 1999 and pigmented limewash applied over in 2006.

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HISTORIC ENVIRONMENT SCOTLAND TECHNICAL PAPER 29

REVIEW OF HOT-MIXED EXTERNAL LIME COATINGS IN SCOTLAND 1997-2016

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PREFACE BY HISTORIC ENVIRONMENT SCOTLAND

Hot-mixed mortars have a long history of use in Scotland, with evidence visible throughout the country on traditional buildings and structures. Since the mid-1990s however, their preparation and use has been largely superseded by dry-bagged Natural Hydraulic Limes (NHLs) that have different properties to their historic predecessors. Growing concern about the compatibility and authenticity of modern lime mortars on traditional masonry structures has encouraged a revival of interest in the use of hot-mixed mortars for repair and conservation. This HES series of Technical Papers aims to assist practitioners in understanding the evidence which supports the historic use of hot-mixed mortars, and why these materials are still relevant. It serves as a starting point for discussion on the continued revival of traditional mortars in Scotland and how they fit into the wider range of mortar repairs for traditional buildings.

Hot-mixed mortars are prepared by mixing quicklime with aggregate and water, generating heat and producing a sticky, lime-rich mix. The benefits of hot-mixed mortars are well-known by practitioners and craftspeople, and have been documented in historic and recent texts on traditional building and conservation. They are favoured by many practitioners for their workability and early stiffening, allowing efficient building and economy of materials. Despite reservations amongst some practitioners about the predictability and durability of quicklime-based mortars, they have nevertheless been used for the repair and reinstatement of external lime coatings on a variety of conservation projects in Scotland in recent years. The range of case studies presented here helps to establish an evidence base for the use of hot-mixed mortars on an array of buildings and structures, in various geographical locations and levels of exposure. The 24 case studies presented in this paper consider how these external coatings have performed and what factors have affected their performance over time.

This Technical Paper is one of a series that considers various technical aspects of hot-mixed lime mortars. These Technical Papers consider the historic evidence for the use of hot-mixed mortars from written sources; the micro-structure and performance of historic mortars; the historic evidence still on buildings in Scotland today; and the specification of hot-mixed mortars for new projects. It is hoped that by revisiting and assessing relatively recent projects, lessons can be learned for those who are tasked with developing appropriate repair and conservation strategies for external coatings on similar buildings elsewhere in Scotland.

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OVERVIEW

Introduction

Over the past few decades there has been a growing interest in the re-discovery of hot-mixed lime mortars for the conservation and repair of traditional buildings. Hot-mixed lime mortars are broadly defined as those prepared by adding quicklime to aggregate and water and mixing together to form a mortar ready for immediate use, alternatively it can be left to cool partly or fully before use.

In recent years a discussion on these types of mortars has taken place through a range of conservation organisations and practitioners. The perceived advantages and disadvantages have often been presented relative to other mortar types such as lime putty and Natural Hydraulic Limes (NHLs). Such comparisons are often helpful and justifiable, however occasionally they have been misguided, particularly given recent Scottish experience with the use of gauged or hybrid mixes containing more than one binder type; typically an air lime (non-hydraulic) in the form of quicklime or putty gauged with an NHL.

This publication focuses specifically on the use of hot-mixed lime mortars for external coatings to traditional buildings. In Scotland, these are most commonly harling. Further details on harling, and other types of external coatings can be found in 'TAN 15: External Lime Coatings for Traditional Buildings' (Historic Scotland, 2001).

Case Studies

This project identified traditional buildings and structures in Scotland where hot-mixed lime mortars had been used for the repair or re-instatement of their external coatings since the 1990s. Several individuals and organisations assisted with compiling a list of relevant projects, and particular thanks are due to the many craftspeople who assisted, along with the Scottish Lime Centre Trust.

Predominantly, the projects visited and described in this publication are harled and limewashed buildings. It was also decided to include a few examples of fully flush pointing finishes. No examples of flat lime renders (external plaster) utilising hot-mixed lime mortars were identified from within the given time period. From the initial list of relevant projects, a representative selection of 24 buildings was selected. Each was visited, and an external inspection undertaken, with a view to recording their current condition and assessing, in general terms, the performance of their external harling or pointing finishes. These visits took place between September 2016 and March 2017. Of the buildings visited, most were inspected from adjacent public roads or footpaths. In some cases, access was arranged with the building owners and/or occupiers.

Specifications

All projects included within this publication used hot-mixed lime mortars for harling and pointing finishes based on CL90 quicklime: aggregate, gauged with NHL. For some projects, detailed specification information such as the mix ratios and type/grade of NHL was obtained from owners or contractors; for others this information was not reliably recorded. It was therefore decided not to include details of exact mixes used.

Where known, the mortar mix specifications differed across the range of projects. The relative proportions of quicklime to NHL varied considerably, as did the type/grade of NHL gauging, although in the case of the latter, NHL5 and NHL3.5 were most commonly used. In respect of the relative proportions of quicklime to NHL, this varied from 0.5 parts NHL: 1 part quicklime at the 'less hydraulic' end of the scale and 2 parts NHL: 0.25 part quicklime at the 'more hydraulic' end of the scale.

Arguably, some of the 'more hydraulic' mixes might be more accurately described as an NHL gauged with quicklime, however it is important to recognise the significant dilution factor when gauging NHL with quicklime. Firstly, the quicklime expands in volume when slaked. In the case of a CL90 quicklime, a doubling in volume is typical. Secondly, the dilution factor is significant as NHLs are not 100% hydraulic, containing varying proportions of free lime (CaO). Generally, the higher strength grades of NHL contain less free lime than the weaker grades, however there is significant variation between different manufacturers' products. It is therefore important to understand the composition and properties of specific NHL products for use as a gauging into a hot-mixed lime mortar, in the same way that NHL products should be understood in the context of straight NHL: sand mixes.

Observations

Overall, the buildings and structures of the case studies appear to be performing well, with a few exceptions. Where localised failures were observed, these are generally symptomatic of underlying or peripheral defects. Traditional building details and features such as crow steps and areas below window sills, particularly where these have weathered, often create challenging junctions for finishing lime harling and limewash. Consequently, they will always be more susceptible to water staining, weathering and potential damage by frost action. In many cases, however, these issues could be resolved with minor alterations to the detailing and/or selection of materials. A holistic understanding of the building and how it performs is critical to predicting or resolving such issues.

Of the harling projects inspected, the coatings are typically well-adhered to their substrate. This supports practical and reported observations of the mortar being 'sticky' and willing to bond well with its substrate, particularly in the case of hard, impervious stonework.

The expansion of quicklime in a hot-mixed mortar is of no particular advantage in an external coating and could be a disadvantage where slow slaking causes 'popping' and 'pitting' in the coating. Whilst the author has observed this phenomenon, it was not evident in any of the projects visited.

Craftspeople included in the project reported leaving the hot-mixed mortar to cool slightly or fully for harling, particularly for the finish coat. Some reported applying the first coat whilst still hot or warm to aid adhesion, particularly onto masonry with no suction, i.e. hard and impervious stones.

The impact of applying new lime coatings to damp or saturated masonry walls was observed on a number of the case studies. There should be an expectation that an appropriately specified lime mortar or coating will wick moisture from within the wall fabric and permit drying from its surface. It should therefore be anticipated that this process will affect the lime coating visually – damp areas will appear darker, so a coating may appear 'patchy' until moisture equilibrium is reached. In the case of a very damp or saturated wall, the carbonation hardening process can be delayed, and whilst the coatings remain damp they may be at risk of frost damage during, and sometimes beyond, the first winter.

Maintenance

A visible lack of maintenance is evident in many of the buildings inspected, with blocked or otherwise defective gutters or downpipes common. In the author's opinion, some of the rainwater disposal goods appear inadequate to cope with the volume of rainwater run-off from roof surfaces. When such conditions prevail, repeated wetting of harling may ultimately lead to frost damage.

Few of the buildings harled 10-20 years ago appear to have been re-limewashed since. Whilst some display signs of weathering to the limewash, locally exposing the underlying harling, most are in remarkably good condition for their age.

Cracking of harling associated with the use of harder and less flexible coatings was observed on a few of the buildings inspected, though mostly minor. The reported specifications used for these particular buildings were generally at the 'more hydraulic' end of the NHL gauged hot-mixed mortar spectrum, suggesting that careful consideration of the relative proportion of NHL gauging is necessary when designing mixes for lime coatings.

The traditional lime harling detail of 'feathering-out' (reducing the thickness gradually) into wall openings and up to crow steps and skew stones was observed in only some of the examples inspected. In other cases, the overall coating thickness observed was greater than that more

commonly found in historic examples. It was also observed that where 'more hydraulic' mixes had been used, many of the thinner areas of harling are detached or cracked and/or boss. 'More hydraulic' lime mixes (as with cement based coatings) typically require a greater thickness to avoid cracking and detachment, but this can detract from the traditional character and appearance of the harling and building.

Harling defects at ground level are not uncommon, particularly where the full thickness of harl has been taken down to ground level and is essentially wicking moisture up from the ground by capillary action. Harling which has survived better tends to be that which was feathered-out towards the base of the wall, or even finished just above ground level (but usually limewashed to disguise it). This reduces the capacity for wicking through the harl itself. Those buildings which have some form of maintained drainage at the base of the wall are generally less affected by defects at this point.

Summary

This Technical Paper provides evidence for the use of hot-mixed lime mortars for external finishes to traditional buildings. The case studies demonstrate that NHL gauged hot-mixed lime mortars have been used successfully for the last 20 years and continue to be specified and used by craftspeople and consultants with the appropriate knowledge and experience to do so. They also demonstrate some of the limitations of lime harling and limewash performance when repeatedly wetted or saturated due to defective or inadequate rainwater disposal and/or building detailing. Therefore, the case studies establish the need to holistically consider the water handling capability of the building as part of any harling or re-harling project. The timing of the work and the need for drying periods must also be considered as part of the building repair and specification process.

I. Alexander Scott's Hospital, Huntly, Aberdeenshire

Date of works: 2014

Client: Private



Figure 1.1 Main entrance, south-facing elevation.

The work on the hospital was supported by a grant from Historic Environment Scotland. The building has lime harling to the front, gable (side elevation), rear elevation (east side) and rear recess. The harling is an NHL gauged hot-mixed lime mortar, with traditional hand-cast finish throughout, and is consistent in terms of its texture and general appearance. It is finished with a limewash which also seems consistent in terms of its colouring. The harling appears to be well bonded to its substrate with no cracking observed, and is neatly feathered into the stone dressings. There is little evidence of any erosion or disruption, even below the window cills, where the harl is slightly proud of the stone. Locally, at ground level terminations, the harl is affected, though not significantly, by rising damp. No bossed harl was detected at these locations. Minor algae and water staining is apparent on the gable and rear elevations, with this particularly noticeable within the "L shaped" recess on the rear elevation, where air flow is restricted.



Figure 1.2. Harling to the front elevation, east side of the tower. The harl and limewash all appear to be uniform and in a sound condition.



Figure 1.3 Rear elevation, the harl and limewash all sound, with the exception of rising damp and some mechanical damage at ground level.

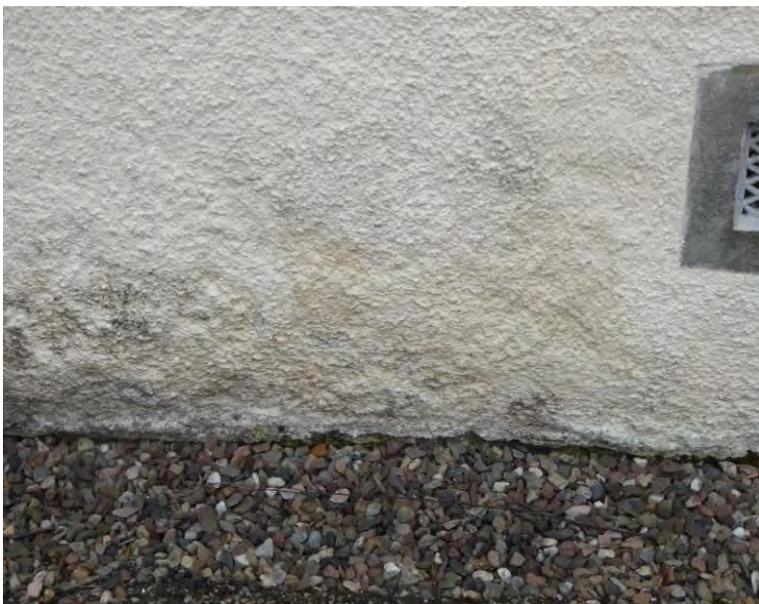


Figure 1.4 The harl at ground level on the rear elevation, showing some staining from rising damp, however, it remains well bonded.

2. Christ Church, Huntly, Aberdeenshire

Date of works: 2016

Client: The Scottish Episcopal Church



Figure 2.1 The front elevation, viewed from the south-east.

The work here were supported by a grant from Historic Environment Scotland. The building's harling is applied to the front, gable (side elevation), rear elevation (east side) and rear recess. It is an NHL gauged hot-mixed mortar, and a traditional hand-cast finish throughout which is consistent in terms of its texture and general appearance. It is finished with a limewash which also seems consistent in terms of its colouring.

The harling appears to be well bonded to its substrate with no cracking observed. It is neatly finished into exposed stone window/door dressings, buttresses and quoins, feathered in where appropriate. A few areas of moisture within the harling and/or limewash were observed, particularly to the west gable. These areas generally have the appearance of moisture within the harl itself, due to its recent application and completion, or residual moisture within the wall fabric drying out, as would be expected.

Some water staining to the harling was also observed adjacent to the downpipe at the porch, possibly due to overspill or leakage from the rainwater goods.



Figure 2.2 View of the west gable with bell tower. The harl and limewash are well finished and appear sound at this time. The limewash at upper levels shows the effect of wetting drying cycles.



Figure 2.3 Slight patchiness was observed on the east gable, which is not uncommon in limewashed harl, particularly following periods of rainfall and subsequent drying.

3. Craigievar Castle, Alford, Aberdeenshire

Date of works: 2009-10

Client: National Trust for Scotland



Figure 3.1 View from the south after a period of heavy rainfall.

The work to the castle were supported by Historic Environment Scotland's Annual Repair Grant to the National Trust for Scotland. The harling is an NHL gauged hot-mixed mortar, limewashed. The lime harling and pigmented limewash were applied during 2009-10 to replace a previous cement based harling that had been put on in the 1970s. The lime harling is all hand-cast. The harling and limewash appear to be performing well, with the exception of localised areas affected by moisture, principally rainwater run-off and splash back. Rainwater can be observed draining off the high level detail, and from the water spouts at the upper string course. Some of this water is being blown back onto, and draining down, the face of the harling. This is resulting in saturation of the harl and limewash, localised erosion of the limewash, soiling and algae growth.

The harl appears generally sound as confirmed, where accessible, by tapping. In addition to the wetting of the walls by windblown spray, water shed from high level spouts is landing close to the base of the wall with splash back damage observed on the low level limewash.

Localised patch repairs and re-limewashing were observed at ground level. In an attempt to address erosion and pitting of the ground surface, granite sets have been laid. These have resulted in splash back affecting the harl at ground level.



Figure 3.2 View of an area of wall, at first floor level on the west elevation, where the harl and limewash appear sound. No discolouration or erosion was detected at the cills, as is common below large windows where water sheds faster.



Figure 3.3 View of water spouts at third floor level all contributing to water discharge that is impacting on this corner at ground level.



Figure 3.4 Impact of water discharged from the high level area.

4. Tower at Drum Castle, Drumoak, Aberdeenshire

Date of works: 2013-14

Client: National Trust for Scotland



Figure 4.1 North elevation of the tower.

The work on the tower were supported by the Annual Repair Grant given by Historic Environment Scotland to the National Trust for Scotland. Although the building does not have a full harling, the tower at Drum Castle was repointed, fully-flush (or slaister), using an NHL gauged hot-mixed mortar and given a scraped finish. On the north elevation, the mortar appears generally well bonded and there is good adhesion between the stone and the feathered mortar edges. The patchy appearance of the mortar, observed on all elevations, is possibly due to the poulticing effect of the lime mortar drawing moisture (and salts) from the underlying saturated wall fabric. There has been a long history of damp in this building, and although this is now understood to have been addressed, there is an expectation that the substantial thick masonry walls will take many years to dry out. In the meantime, the poulticing effect of the external lime work, replacing much of the previous cement work, will inevitably impact upon the appearance and durability of the external lime work.

On the north and east elevations the masonry is generally dry and there were no obvious indications of saturation of the mortar or evidence of water run-off patterns.

Localised lime leaching and areas of bossed and/or flaking mortar were observed on the west elevation, with this generally concentrated at the margins to stones and not within larger areas of mortar between stones.

It was noted that the most affected areas of disrupted mortar are surrounded by, or adjacent to, areas of retained cement mortar and this may be overstressing the lime mortar. Again, this is perhaps due to the poultice effect of the lime mortar, and moisture within the underlying wall fabric, confined by the presence of the cementitious mortars.

There are also some areas of bossed mortar on the lower levels of the south elevation, but a reduced occurrence of cracking was apparent. The mortar pointing at this location is locally proud of stones, forming ledges at the stone margins, and some of these may drain rainwater inwards towards the stone margins. There is some frost damage to the south-west corner, on the west face, again below and adjacent to an area of cement mortar. The majority of the pointing, however, appears to be sound and performing as intended.

The pink area in Figure 4.2 is not a plume of damp but surviving areas of a 19th-century sneck harl. This exposed corner shows indications of retained moisture, leaching and spalling due to frost attack. There are also areas of retained cementitious pointing overlying and adjacent to the areas of disrupted pointing. It may be that its retention is contributing to the degree of saturation indicated at the areas of disrupted pointing.

Part of the west wall has all the typical features of wet mortar affected by frost damage, causing failure. The leaching shows that the wall is still wet. This may be a consequence of poor parapet drainage or water being played down the wall from the spouts above.



Figure 4.2 View of the south-west faces of the tower, affected by localised cracking and spalling of the mortar.



Figure 4.3 The east elevation of the tower, where the pointing appears to be performing well.



Figure 4.4 Section of pointing on the west wall, where scaling mortar and leaching of lime were observed. This example is directly below one of the parapet water spouts and adjacent to a large section of retained cement based pointing work.

5. Garden Bothy, Fyvie Castle Estate, Aberdeenshire

Date of works: c.2003-4

Client: National Trust for Scotland



Figure 5.1 Front (north) elevation, viewed from the north-east.

The building is constructed from sandstone rubble finished with a lime harl which has been limewashed. It is understood that an NHL gauged hot-mixed mortar was used for the harling. The work was supported by Historic Environment Scotland's Annual Repair Grant to the National Trust for Scotland. From tapping the coating and visual inspection, the harl appears to be generally sound and well bonded to the substrate. However, adjacent to the openings there is local damage from impact and abrasion; water damage has arisen from faulty rainwater goods and rising damp or water splash against the walls.

The loss of harl appears to have occurred where the harl was applied over the top of sandstone dressings at door surrounds and window lintels; in these cases the harl is typically less than 5mm in thickness. Where the harl was applied at a greater thickness over stone dressings it is still mostly attached. Discolouration of the limewash was observed, particularly where water run-off from the roof and cills was apparent. The building has not been re-limewashed since the date of the works.

The loss of harl over the doorway may be due to the nature of the stone. It is smooth with various paint coatings still adhered which may have prevented the harl bonding with the stone.



Figure 5.2 West gable, with the limewash and harling over most of the wall area in good condition. The exception is at ground level which is marked by soiling and wetting due to long term splash back from rainwater dripping from the roof.



Figure 5.3 Rear elevation, with discolouration and some spalling from water damage. This is possibly caused by rainwater overtopping the gutters below the large rooflight.



Figure 5.4 Loss of harl from the lintel and the sandstone dressings to the ingo at the east doorway on the front elevation.

6.66 High Street, Dundee

Date of works: c.2000

Client: Private



Figure 6.1 Front elevation showing the generally good condition of the harling.

This is a late 19th-century masonry building with a thin, lime harl applied over the stonework. The harl is an NHL gauged hot-mixed mortar and is sufficiently light to permit the shape of the underlying masonry stones to reflect through it. Yellow coloured limewash was painted over a finely textured finish. The works were carried out in the autumn and winter of 2000, normally not customary months for lime work. The works were supported by Dundee Council's Facade Enhancement Grant Scheme. The harl appears to be thinly coated, possibly displaying a dragged finish to enhance texture and impart a uniform appearance across the elevation.

Some slight cracking was observed above the shop front boarding, indicating mechanical damage caused by working on the signage. The window dressings and cills all appear good, with minor localised cracking below the cills at first floor level, above the close entry. There is erosion on the chimney with localised staining and spalling (very small areas) below the roof level gutter. Staining and localised erosion are also apparent adjacent to the downpipe on the right side of the facade. This is due to poor drip detailing on the chimney head and the splayed shoulders of the

chimney stack. However, visually the harl appears to be in generally good condition despite having not been limewashed since 2000. There is some staining at high level due to rhones that have become full of debris. While the limewash is in good condition, it must be remembered that this is a drier part of Scotland and a sheltered urban location.



Figure 6.2 West side of elevation at roof level, showing some localised disruption of the harl from running water due to a blocked rhone.



Figure 6.3 View of harl just above a first floor window, some faint horizontal cracking and discolouration of the limewash below the cill can be seen due to water draining over the cill.

7. Anstruther Wester Church & Dreel Halls, Anstruther, Fife

Date of works: 2013-14

Client: Anstruther Improvements Association



Figure 7.1 The front (west) elevation.

The harling on this building is a traditional hand-cast finish over rubble stone masonry that was mixed using an NHL gauged hot-mixed lime mortar. Works were supported by funding from Historic Environment Scotland. The harl is painted with a pigmented limewash and it appears to be generally sound and well bonded to the masonry, with a few localised exceptions.

The most obvious issue with the building is its blotchy or patchy appearance. The limewash finish is discoloured in a number of locations principally on the west and south elevations. The reasons for this vary, but both elevations are by the road and are affected by apparent road splash/spray and rainwater splash back from hard pavement surfaces. The west elevation in particular abuts a narrow main road with heavy traffic and there is evidence of ponding of water due to uneven road surfaces. The black coloured staining appears to be splash back of dirty surface water from the road, but could also be salts or contaminants coming out of the walls.

The limewash on the north elevations of the hall and tower is discoloured but to a lesser degree and the harl appears otherwise sound. The discolouration apparent here, and on the east wall, is likely due to the walls continuing to dry, carrying salts with iron oxides from within the previously saturated wall fabric to the outer surface of wall finishes. Issues of water run-off and rising damp are also apparent on these walls.

It is understood that the building was derelict for several years prior to the works, and the masonry contractor reported that many areas of limewash discolouration are due to particularly damp areas of wall fabric caused by previously defective rainwater goods and leaky roofs.

The harling and limewash on the south elevation (east end) of the church is suffering from a previous defect with the roof gutters. Channelled water flow down the wall face has resulted in erosion and damage to the harling. A similar pattern, but with a lesser degree of damage to the harling, can be seen to the west end of this elevation. However, the rainwater goods on this elevation appear to have been modified, possibly resolving the problem.



Figure 7.2 North elevation, where the harl appears sound and well bonded. Localised discolouration seems to be due to water run-off and from drying of the previously saturated walls.



Figure 7.3 East elevation, which is generally in a sound condition, with localised discolouration of the harl, again due to both rising and draining dampness and the drying of the wall fabric below.



Figure 7.4 Close-up of the erosion damage at the east side of the south elevation, caused by blocked or poorly configured rainwater goods above, now rectified.

8. Harbour House, Pittenweem, Fife

Date of works: 2015

Client: Private



Figure 8.1 Front (south-east) elevation, showing the uniform appearance of the limewashed harl over the full elevation.

The building's lime harl appears to be a traditional hand-cast finish and is an NHL gauged hot-mixed mortar. The harl finish has been lightly pushed back with a float to impart a flatter overall texture to the wall surface. The harl is painted with a pigmented limewash.

This relatively recently applied harl and limewash appear to be in good condition, surviving well in the coastal location. Some very localised erosion to the harl and limewash was observed on the south-west side, which appears to be due to water run-off, apparently channelled from a gap at the end of the gutter. This has been further aggravated by water draining down off the skew and missing the gutter.



Figure 8.2 View of an area of harl, to the west of the easternmost window, at first floor level. Here the subtly undulating profile and texture of the harl can be seen to be enhanced by the warmth of the limewash coating.



Figure 8.3. West side of the facade, at low level, where damage to the surface is evident. There has also been localised loss of the finish coat and limewash to the window dressing of the westernmost window.

9. Monimail Tower, Monimail, Fife

Date of works: 1999, re-limewashed 2006

Client: Monimail Tower Preservation Trust



Figure 9.1 View of the west elevation of the tower, from the north-west, showing the slight colour variation in the limewash.

The harling in this case is a traditional hand-cast finish, with a pigmented limewash applied over. It is understood that the harling is an NHL gauged hot-mixed lime mortar; it is in generally good condition. The works were supported by grant funding from Historic Environment Scotland. Minor erosion is apparent on the upper part of the east elevation directly below the parapet level string course, where erosion of mortar from open perpend joints has resulted in very localised channelled water flow over, and into, the harl. This has caused localised disruption and loss of surface from frost scaling. It also appears that the string course overhang or drip is insufficient for increased levels of precipitation.

Localised cracking in the mortar jointing to the chimney masonry was observed on the north and south elevations. This appears to be allowing water ingress into the wall fabric that is percolating down onto the harl on the south elevation, below the parapet level. However, this has reportedly only become apparent after the installation of a flagpole which was anchored against the east side of the chimney masonry, and it is considered that the cracking has been induced due to localised movement in the chimney masonry rather than as a deficiency in the harl itself.



Figure 9.2 View of the south-east corner, with the localised area of disrupted harling apparent just below the string course on the north side of the east elevation.



Figure 9.3 A close up of the upper part of the tower on the south elevation where a crack was observed below the chimney. Note the additional weathering below the open joint in the string course.

10. North Range of Culross Palace, Culross, Fife

Date of works: c.2016

Client: National Trust for Scotland



Figure 10.1 View of the north range, rear elevation.

The north range of Culross Palace was harled in an NHL gauged hot-mixed mortar. The works were supported by the Annual Repair Grant given to the National Trust for Scotland by Historic Environment Scotland. The harling has been limewashed with a pigmented limewash. On these elevations, the harl has the appearance of a traditional hand-cast application that has been lightly pressed back, producing a tight, relatively uniform surface texture. It is visually uniform and appears to be well bonded to the substrate.

There is lightening of the colour of the limewash where there is water runoff over the harl surface. This is particularly noticeable where channelled drainage from the dormer windows has occurred, and is apparent below all three of the dormer windows on this elevation. Despite this local effect, the limewash appears uniform and well burnished. However, as is common with pigmented limewashes, there are shading variations across all three elevations. This should not be seen necessarily as a defect, but rather as a feature of its evolving character.

At high level, there is minor staining and algae growth on the harling and limewash on the chimneys and crow steps. This is due to water run-off as there is no water shedding detail. In addition there is damage from the passage of water through eroded mortar joints at both the crow steps and chimney copes. It was noted that on all elevations the harl was terminated approximately 30-50mm above ground level, which seems to have limited the impact of ground water absorption into the harl and reduced the impact of splash back from the surrounding hard paving.



Figure 10.2 View of the east gable of the east extension. Staining at the crow steps is clear, as is blotching from salts within the wall lower down.



Figure 10.3 View of harl close to ground level. The harl has been terminated just above ground level to minimise wicking.

11. Dantryfail Cottage, near Strathpeffer, Highlands

Date of works: 2015

Client: Private



Figure 11.1 The west gable of the cottage.

The gable of this 19th-century cottage was harled with a traditional hand-cast finish, in an NHL gauged hot-mixed mortar. The high points of the harl have been lightly pressed back with a float, and finished with a white (uncoloured) limewash. During the works, care was taken to ensure that the joints in the skew copes were pointed. The area around the base of the wall has been graded and covered with gravel.

The harling finish is consistent and well executed, and appears to be sound and fully bonded to its substrate. The limewash has been thinly applied and well burnished with no evidence of chalking. The harling has been neatly finished to the underside of the skew copes and chimney stack base. The absence of any staining is likely due to the care of the copes. Lower down, the good condition of the harling at ground level is a result of the gravel minimising splash back.



Figure 11.2 Close-up of the harling termination at the chimney.



Figure 11.3 Base of the wall, showing harling carried on down to ground level.

12. Former Assynt Parish Church, Inchnadamph, Highlands

Date of works: c.2003

Client: Historic Assynt



Figure 12.1 Front (south) elevation.

This 19th-century church was renovated during 2003 when it was re-harled and limewashed; it has not been re-limewashed since. The works were supported by a grant from Historic Environment Scotland. Some areas of earlier harling remain to the east gable and north elevation, and these were patched into with an NHL gauged hot-mixed mortar. The harling appears to be generally sound. Given the location and extreme exposure of the building, both the limewash and harl are performing well. Minor bossed areas and localised disruption was also apparent at ground level on the rear (north) elevation.

Localised cracking of the harl was noted on the south elevation where, at all four windows, cracks extended down from window openings. These all occurred at the east side of the cills, having the appearance of reflective cracks from movement of the underlying masonry. Rhones on both the front and rear elevations require attention, with the downpipes on the north side blocked, resulting in water cascading down the walls from roof level. This has caused localised erosion and accelerated decay of the limewash and harling.

A lack of drip detail below the window cill has resulted in staining of the limewash and some localised decay of the harling. Attention is also required at roof level, on the north side, where the bottom row of slates is displaced, causing water to miss the gutter and run down the wall face, affecting the limewash and harling.

The east gable appears to be the most protected from the weathering and as such is in very good condition. The west gable, being the most exposed to the weather, has lost much of its limewash finish. This is likely due to wind and rain abrasion, however, it should be noted that the underlying harl appears sound.



Figure 12.2 Window on the south elevation. The flaggy stone cill is deteriorating, as are all cills on this elevation, with a crack on the east side of window. Although there is evidence of channelled water flow over the cill, the underlying harl is sound and the limewash in relatively good condition.



Figure 12.3 The lime harling on the very exposed west gable remains in good condition. There is some loss of limewash, which is to be expected due to the exposed nature of the site.

13. St Andrew's Church of Scotland, Aviemore, Highlands

Date of works: c.2004

Client: Church of Scotland



Figure 13.1 General view from the south-west.

This granite church was repointed around 2004. The finish to all except the front (west) elevation is a fully-flush or slaister pointing with a relatively flat, but scraped, finish which has been subtly lined-out. Whilst not a full coating, as in the case of a harling, the overall mortar surface area is considerable and will perform, in some respects, in a similar way to a thin harl coating. The mortar is generally well bonded to the stone, particularly where it is feathered onto the surface of the masonry.

The mortar is understood to be an NHL gauged hot-mixed mortar. An abundance of small lime inclusions has been exposed where the surface of the mortar was scraped back. This is more visible where the outer surface has been lost due to abrasion or frost-initiated spalling, though these areas are very limited in size and regularity. Localised bossed areas were found below some window cills to the north elevation in relation to water run-off; this is common where there is no projecting cill or drip.

The windows on the south elevation appear to display the same problem as those observed on the north elevation, with water run-off from cills

causing localised spalling and surface erosion. Although the mortar is mostly well bonded, there was a higher incidence of small bossed areas detected, which is perhaps due to the effects of solar gain acting on this elevation.

However, generally the pointing was well executed and is performing effectively. In particular it was observed that the junction between the mortar pointing and the granite stone was tightly sealed with no evidence of cracking. This indicates the effectiveness of a hot-mixed mortar in forming a successful bond with a hard stone type.



Figure 13.2 Close-up of an area of the pointing, showing a generally tight finish with a relatively uniform texture and finish.



Figure 13.3 Close-up of one stone showing the mortar feathered over the edges of the stone, both effectively flattening the wall surface and displaying good adhesion to the masonry.

14. Upper Coul Cottage, Strathconan, Highlands

Date of works: 2014

Client: Private



Figure 14.1 The front elevation, viewed from the south.

The cottage is constructed of traditional rubble stone bedded in clay mortar, pointed and newly harled and limewashed. The harling is an NHL gauged hot-mixed mortar with a pigmented limewash. It is understood that a more robust mortar mix based on an NHL: sand mix was used on the chimneys due to the higher degree of exposure at roof level. The limewash finish was reported to consist of two coats of white and three to four coats of pigmented limewash.

The harl and limewash are both in good condition. The harl appears to be well bonded and applied to a consistent finish, pressed back slightly. The limewash is evenly applied and well burnished into the harling with no evidence of chalking or cracking observed. There is slight discolouration of the limewash at the window cills to the south elevation caused by rainwater run-off. There is some minor and localised loss of limewash from the copes on both chimneys due to an eroded cope edge on the north and west sides.



Figure 14.2 North elevation, west side. The harling is slightly textured and undulating following, to some degree, the profile of the masonry.



Figure 14.3 West gable, showing the natural variation in colour that is achieved with a well burnished pigmented limewash.

15. Wardlaw Mausoleum, Inverness, Highlands

Date of works: 1997-98

Client: Wardlaw Mausoleum Trust



Figure 15.1 General view of the Wardlaw Mausoleum, viewed from the south-east.

The Wardlaw Mausoleum originally dates from the early 17th century. It was refurbished between 1997-98 and the harling was repaired as part of these works. The works were supported by grant funding from Historic Environment Scotland. Existing lime harling was patched with new matching lime harling, all of which was then limewashed. The building has not been limewashed since. The new harling and patch repairs were composed of a lime putty: sand coarse stuff to prepare backgrounds, and a hot-mixed coarse stuff for the harling; both mixes were gauged with an NHL. The quicklime for the harling was locally sourced and burnt on site in a small kiln. The sand for the harling was sourced from a local river bank. The hot-mixed mortar component was used cold after maturing on site for a few weeks. A hot-mixed grout (used hot) was also used to fill and consolidate areas of wallhead.

The condition of the harling is good, with areas of localised damage. On the south elevation there is minor discolouration and some erosion to the limewash and harling due to water run-off from skew copes. Blocked or

undersized rhones are causing water to stain and damage the harling in this area. The effect of water run-off is also apparent below the windows. There is some evidence of rising damp, but the harling and limewash appear intact and fully bonded to the masonry.

The east gable has some staining to the limewash and harling due to water run-off at the skewes and from the step in the bell tower, but no loss or decay of the harling itself was noted. The north elevation is generally sound although there are small disrupted patches of harl, their shape suggests localised physical impact damage. Where the surface of harling is broken, the mortar is relatively soft and friable but intact. In the north-west corner there is evidence of water run-off from the skew. This has caused the limewash to be stripped, however, the harling appears intact. Likewise, on the west gable the harling and the limewash are in good condition even through there is evidence of water run-off from the skew. The skew has algae growth.



Figure 15.2 South elevation, showing the staining from water run-off below the cills and the damage from the overflowing of the rhones at the wall head.



Figure 15.3. The east corner showing the well feathered junction with the sandstone quoins.

16. Coxton Tower, Llanbryde, Moray

Date of works: c.2002 and 2010

Client: Private



Figure 16.1 Front elevation viewed from the south-east.

The tower was re-harled in 2010 with a hydraulic hot-mixed harling, and also limewashed. Unlike most other projects within this report, the quicklime had a hydraulic component. This type of material is hard to procure but the contractor had access to supplies. The limewash was made from an NHL2 and was not pigmented; the warm colouring is the natural colour of the lime and its constituent minerals.

It is understood that the 2010 re-harling followed a previous phase of consolidation of the masonry fabric. This included some early or original harl, which was retained, patched with the new harling and unified with the limewash finish. The condition of the harling is variable with some elevations in good condition and others in poor condition.

The front elevation faces south-east and there is localised disruption of harling at the wall head and again at ground level, however, around 95% of the surface area of harl and limewash appears to be sound and in good condition. The areas in poor condition have been acted upon by moisture; rainwater from overtopping or faulty guttering at the wallhead and rising moisture and/or splash back at ground level.

The harling and limewash finish to the south-west elevation appear visually sound, with only minor and localised disruption of the harl observed, again at the wall head and ground level. The north-east elevation shows the most extensive failure of the harling. The damage appears to be mostly due to water drainage onto the wall fabric, with saturation and frost damage. Most of the disruption observed appears to be due to detailing issues and the malfunction of rainwater goods at high level.



Figure 16.2 Extensive failure of the harling on the upper part of the north-west elevation, where there is total saturation of the wall head, probably due to poorly detailed rhones and a blocked downpipe.



Figure 16.3 Base of the south-west elevation showing the harling and limewash to be in good condition.

17. New Elgin Doocot, Elgin, Moray

Date of works: c.1999

Client: Moray Council



Figure 17.1 South side of the doocot, with intact harl, viewed from the south.

This late-medieval doocot was refurbished c.1999 when a hard, external cement render was removed and the structure was re-harled in lime mortar, with a limewash finish. It is understood that the harling was an NHL gauged hot-mixed mortar. The doocot is currently used by wild birds.

The limewash is now heavily eroded, unsurprising given the shape of the structure and the fact that some 18 years have passed since it was last limewashed. Since there is a degree of drip detailing between the different levels of the building, the masonry of this structure is prone to saturation. However, the matrix of the harling remains generally sound, and tapping indicates it to be well bonded. At low level the harl surface is marked by graffiti, and at higher level with patches of mould and algae colourisation. Some of the graffiti has been overpainted with what appears to be a modern masonry paint, presumably to mask it. Locally there is some surface weathering of the harl, but this appears to be confined to the outer surface, typically where exposed as a result of the loss of the protective limewash coating.



Figure 17.2 North side of the doocot showing the generally sound condition of the harl.



Figure 17.3 Localised erosion of the surface just below the lower stone rat ledge on the west side.

18. Kincarrathie Doocot, Perth

Date of works: 2011 (replacing earlier defective lime harling), re-limewashed in 2012

Client: Gannochy Trust



Figure 18.1 General view showing the front (south) elevation; photo taken after heavy rain.

The harling on this structure appears to be a hand-cast finish, limewashed. It was inspected immediately after a spell of heavy rain, which allowed easy identification of areas of run-off and staining. It is understood that the existing harling is an NHL gauged hot-mixed mortar and was applied in 2011, replacing an earlier defective lime harling. The harling and limewash are in generally good condition. Roof copes to the rear (north) wall seem to have open joints allowing water to drain into the parapet upstand. The perpend joints to the copes on the side (gable) elevations appear to have open joints leading to water accessing the wall head and channelling water flow over the harled surface below.

The absence of a method of collecting and disposing of rainwater drainage from the roof has resulted in channelled run-off from the roof interacting with the incomplete slate landing shelf. There appears to be a number of substrate issues affecting the harling, with patchiness and localised cracking observed. Further investigation would be required to ascertain the causes.

Given the use of the building as a doocot, it is likely that the stone around the nesting boxes has a high nitrate content. This is caused by salts accumulating from guano within the permeable masonry wall fabric and affecting the external harling and limewash. Capillary rise is evident around the base of the building, most noticeably at the door opening where the water appears to be wicking up the sandstone dressings behind the harl.

Cracking, similar to that seen on some cement renders, is apparent in the harling on the rear (north) elevation and on the east side. This may be a combination of reflective cracking from the masonry below and shrinkage/thermal cracking in the harl. Such a fine matrix of cracks indicates a hard finish, possibly with a higher than normal hydraulic component not giving much flexibility.



Figure 18.2 View of the west gable, showing extensive discolouration. This is mostly due to insufficient overhang on the skew cope above, and wind driven rain having recently played on the surface.



Figure 18.3 Rear (north) elevation, where the narrow overhang on the wall head cope is insufficient to keep water off the wall.



Figure 18.4 Close-up of the copes on the north elevation, east side, supporting moss and algae, demonstrating that they are holding moisture. The affected copes also display localised loss of fabric. An open joint can be seen in the cope, shown in the upper right side of the image. Water is draining through the open joint, flowing along the wall head below the cope and draining down over the harl below. There is the additional possibility that moisture is accessing the wall head at this location and wetting the wall behind the harl.

19. Abbey House, Melrose, Scottish Borders

Date of works: 2015

Client: National Trust for Scotland



Figure 19.1 View of the front elevation from the south-west.

The harling is a traditional hand-cast finish throughout, finished with a limewash. These are both relatively consistent in appearance across the external walls. The harling is an NHL gauged hot-mixed mortar and limewash made on site from freshly slaked quicklime, applied whilst hot/warm. The harling appears to be well bonded to its rubble stone substrate with no visible cracking observed and, except for the details below, it is doing well.

On the front elevation there are sections of rising damp at low level, with areas of recent patching. This was particularly noticeable by the front door, where there appears to be a blocked drain, with repair to the harl at ground level continuing to extend from the doorway westwards. The east gable looks sound except, again, for localised damp patches at high level and indications of rising damp at ground level. The west gable shows some evidence of damp, particularly at the skews and below the sloping stone flag roof to the extended wall section. In addition, there was localised evidence of rising damp at ground level, affecting the wall up to 100mm above the ground surface.

The north elevation also shows evidence of the walls being damp, particularly adjacent to the paved walkway. Here the walls appear to be affected by rising damp; splash from the paving and the run-off is affecting the wall below the window cills. The harl texture varies slightly with some areas coarser than others.



Figure 19.2 Evidence of rainwater wetting the wall below the north skew on the west gable, where water is running off the skew copes onto the gable.



Figure 19.3 Staining of the harl of the stepped extension on the west gable, where the drip detailing is damaged or insufficient.



Figure 19.4 Localised spalling at low level in this area of repair.

20. Harmony Cottage, Melrose, Scottish Borders

Date of works: c.2001 with later repairs to the gable end

Client: National Trust for Scotland



Figure 20.1 Front elevation of the cottage.

The cottage's harling is a traditional hand-cast finish with a subtly pigmented limewash applied over it. It is understood that an NHL gauged hot-mixed mortar harling was used. Generally the harling and limewash are doing well. At the base of the front elevation there are indications of rising damp up to 300mm from ground level. Moisture was also observed in the harl adjacent to the east downpipe, possibly indicating a current or past blockage in the downpipe.

On the east gable the lower 1.2m to 1.4m seems to have been recently coated over. It is not known what materials were applied or the reason for their application. This has given the wall an uneven colouration. Further investigation would be required to confirm the repair history, materials used and reasons for the harl repairs to this gable.

There is a line of dampness in the wall along the length of the footpath at the junction with the paving on the east elevation. However, this appears to be limited to wicking of surface water from the footpath.

There was no access to the west gable or rear (north) elevation on the day of the site visit.



Figure 20.2 View of the skew putt on the south-east corner, which shows some minor staining of the limewash due to water run-off from the skew putt.



Figure 20.3 View of the east gable, showing the effects of a recent wall coating at lower levels.

21. Haa of Sand, Shetland

Date of works: 2014

Client: Private



Figure 21.1 South-east gable and north-east principal (front) elevation.

Haa of Sand is constructed of local granite with sandstone ashlar dressings. The principal elevations are currently finished with a lime slaister pointing with extensive cement based repairs. Prior to the re-harling of the south-east gable in late 2014, the gables were both finished with a cement based roughcast. The re-harling works were supported by funding from Historic Environment Scotland and the Shetland Amenity Trust.

The lime harling is a single coat NHL gauged hot-mixed mortar containing a relatively low proportion of NHL relative to the CL90 quicklime. A proportion of crushed seashell was added to the aggregate. The harling was then limewashed using a gauged mix of CL90 quicklime and NHL5 to protect the harl.

The harl finish is somewhat vernacular in appearance, being fairly coarse and hand-cast using traditional methods. As would be expected with a single coat application of harl, the plane of the wall undulates with the underlying rubble masonry, though the texture and character of the finish are relatively consistent across the whole gable. Three years after completion, the gable wall is continuing to perform well.



Figure 21.2 Detail of the chimney stack and upper gable, illustrating the harling and the limewash, the latter having been taken over the stone skewes.



Figure 21.3 Detail of harling and limewash finish to south-east gable elevation, illustrating the textural effect of the harl in direct sunlight and the colour variation due to wetting and drying.

22. Haa of Scalloway, Shetland

Date of works: c.2002

Client: Private



Figure 22.1 Front (west) elevation of Haa of Scalloway.

Haa of Scalloway is constructed of rubble masonry (mixed stone types), bedded in earth/clay based mortar and finished with a protective harling.

The harling appears to have been mechanically sprayed and has been limewashed. The harling mix was based on an NHL gauged hot-mixed mortar. It is understood that the original specification was adjusted by the contractor to increase the proportion of NHL relative to the quicklime as the mix was reported to be too sticky for the mechanical spray equipment. Crushed shell was also added.

In sections, the limewash finish has partially or wholly weathered off, particularly in exposed high-level locations such as the chimney stacks and gables. In a few locations the lost limewash has exposed the underlying harling. The grey colouring and apparent hardness of the harling suggests that a relatively hydraulic mix was used.

The photographs show the building shortly after a spell of rainfall, so the short-term wetting patterns can be observed. There are also localised areas of staining/darkening of the limewash which appear to relate

principally to poor weathering details causing saturation of the harl in specific locations.

Some 15 years after the work was carried out, the harling remains largely intact, with the exception of an area below the skews to the south-west corner which is cracked and shows localised detachment. It is understood that the building has not been re-limewashed, or the harling otherwise maintained, since the work was completed in c.2002.



Figure 22.2 South-west corner illustrating a number of defects to the harling; cracking and localised detachment of harl, localised lime leaching and partial loss of limewash.



Figure 22.3 Detail of harling and limewash, with localised area of weathering/decay exposing underlying harl. The shell fragments can be seen in the harl finish.

23. 63 High Street, Linlithgow, West Lothian

Date of works: c.2001-2

Client: Private



Figure 23.1 View of the front (north) elevation.

The front (north) elevation of this building has been harled and limewashed. The harling is reported to be an NHL gauged hot-mixed lime mortar. The harling has been finished with a pigmented limewash and the window margins appear to have been painted with a mineral paint. From the appearance of the harl, and the regular horizontal pattern apparent, it is considered that the harl had either been applied with a harling gun or sprayer. There are also features apparent that may suggest some localised flattening or re-spreading of the harl whilst still plastic at the time of application, with the mortar being applied relatively wet (workable).

The elevation is in good condition and all areas of the harling appear sound. There is no evidence of rising damp affecting the lower levels of the harl, with only very localised indications of retained moisture within the harl, or the underlying wall fabric, with this at the upper west (right) side. The limewash does not seem to have been re-done since the harling works and the only noticeable effect is a washing out of the colour and minor staining from urban pollution.



Figure 23.2 General view of the ground floor elevation, showing intact harl.



Figure 23.3 A close-up of the harl and limewash finish showing the aggregate distribution across its surface. The more open texture may be indicative of a mechanically applied harling.

24. Tower at House of the Binns, near Linlithgow, West Lothian

Date of works: c.2000 with later limewashing

Client: National Trust for Scotland



Figure 24.1 View of the tower from the east.

The tower of the House of the Binns is a round tower constructed of rubble with sandstone dressings. The tower was repointed and harled with an NHL gauged hot-mixed lime mortar as part of major repair scheme. The scheme was supported by Historic Environment Scotland's Annual Repair Grant to the National Trust for Scotland. The limewash used at this stage was mixed with linseed oil and later coats have been added. The limewash is pigmented and there were at least four coats of various colours observed in areas where the limewash and the surface of the harl have been locally eroded. It was also noted that the aggregate used in the harl contained shell and it is understood that this was added as part of the aggregate component of the mortar.

The harling still appears very robust given the height of the structure and its exposed location. It has performed well, and the weathering and erosion is principally restricted to the limewash.



Figure 24.2 View of the upper part of the east elevation showing the weathering and the discolouration of the limewash on the north (right) side of the tower. This side has the most colour variation.



Figure 24.3 Close-up of an area of harl which has suffered from localised erosion, showing the range of limewash coats and the crushed shell.

CONCLUSION

The 24 case studies presented in this Technical Paper establish that hot-mixed lime mortars continue to be used successfully for external coatings on traditional buildings.

Where localised failures were observed, these were principally a result of poor building detailing and a lack of understanding of the decay mechanisms affecting traditional buildings. Lime mortar coatings can be affected by decay caused by de-icing salts, splashback from groundwater, rising damp due to defective drainage systems, and poor handling of rainwater caused by ineffective building detailing. As well, a lack of periodic maintenance, including keeping rainwater goods unblocked and reapplying protective limewash coatings, will place undue pressure on lime mortar coatings and can contribute to failure. The success of a correctly made hot-mixed lime mortar, as with all lime mortars, will greatly depend on an informed understanding of the building and its surrounding environment, and attention to routine maintenance. The functional performance of external lime coatings and finishes, hot-mixed or otherwise, must also be recognised. The sacrificial nature of such materials should remain a guiding principle for their continued use in the repair of traditional buildings, recognising their ability to dry wet or damp wall fabric and preserve historic masonry when correctly specified and used.

Historic Environment Scotland continues to study the use of hot-mixed lime mortars for traditional buildings. Any enquiries about their use, or information which could inform the case studies presented here, should be directed to the Technical Research Team at TechnicalResearch@hes.scot.

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