Refurbishment Case Study 25

HISTORIC ENVIRONMENT SCOTLAND | ÀRAINNEACHD EACHDRAIDHEIL ALBA

HAA OF SAND, SHETLAND

HOT-MIXED MORTAR RE-HARLING AND ADAPTING A GABLE END WALL

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This publication is a web publication and is available for free download from the Historic Environment Scotland website:

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This publication should be quoted as:
Historic Environment Scotland
Refurbishment Case Study 25

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Hot-mixed mortar re-harling and adapting a gable end wall

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Acknowledgements

With thanks to Redman Sutherland Architects and the Shetland Amenity Trust

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Foreword

This case study describes work carried out to an exposed gable of a listed building in Shetland, which had been subject to on-going wind-driven water ingress. In recent years, Historic Environment Scotland (HES) has seen an increase in the reporting of issues caused by water penetration through gable walls, particularly in the west and north of Scotland and in exposed areas. This is likely to be due to a combination of factors including climate change, lack of maintenance, use of inappropriate repair materials and changes to domestic heating resulting in redundant flues and capped chimneys.

Scotland has seen a significant increase in precipitation over the last 50 years, with mild, wet winters and frequent severe weather events becoming more common. Where solid masonry is subjected to persistent driving rain, and has little opportunity to dry out for long periods, damp problems become more likely and more serious. Scotland has always been subjected to severe weather, and in the past many buildings were harled and limewashed, providing protection against the elements; in some cases the external coatings have been lost or degraded, or have been replaced with harder cement products. Cement based harling materials are impermeable, and can be effective while it remains sound. However, such materials can develop hairline cracks as they age, as a result of movement and changes in temperature and humidity. The masonry underneath can become damp, and the impermeable coating prevents the wall from drying out.

Knowledge and understanding of traditional lime practice has become more widespread in recent years, and many buildings have been re-pointed and harled with lime mortars, typically using natural hydraulic lime products (NHLs). Unfortunately there have been some reports of these materials failing, or the damp problems persisting despite work being carried out. Modern limework in many cases is not proving to be as robust and effective as surviving historic lime harling. Inspection and analysis of old lime harling shows many regional variations, but tends to show relatively thin coatings, often based on hot-mixed lime mortars and local aggregates. These materials have different properties to mortars made with modern NHL mortars and may be a better choice for traditional masonry buildings.

This project aimed to demonstrate that despite the increased pressure on buildings as a result of climate change, a combination of maintenance and repair, improving weathering details and the skilled use of appropriate external coatings can improve the resilience of traditional buildings, allowing them to function effectively even in severely exposed locations. The project was supported with grant funding from HES and the Shetland Amenity Trust. The site works were carried out by the Shetland Amenity Trust.

1. Introduction

The Shetland Islands are the most northerly group of islands in the United Kingdom and are exposed to frequent extreme weather in the form of gale force winds and driving rain. Buildings have in the past been adapted to these conditions, being typically low rise, oriented against the prevailing weather, and given external coatings, typically lime '*slaister'* harling, and more recently cement flush pointing and roughcast. In recent years there has been an increase in damp problems in traditional buildings in Shetland, particularly water penetration through exposed gable walls. Haa of Sand is one such building that has suffered in this respect, and required both traditional repair and adaptation to maintain resilience against the weather. The repair and adaption project was initiated by an approach to Historic Environment Scotland (HES) technical advice service, from a local conservation architect in Shetland on behalf of the owners of Haa of Sand.

2. The site

Haa of Sand is a category A listed classically-proportioned Laird's house, occupying an exposed location in the north west of mainland Shetland. It was built around 1754 as a summer house for Sir Andrew Mitchell and is a fine example of polite Georgian architecture (Figure 1). It is constructed from local Hildasay granite with sandstone ashlar dressings. The principal elevations are finished with a lime slaister point, with extensive cement-based repairs. Both gables were finished with a fairly thick (more than 10mm) cement-based rough-cast.

Figure 1: Haa of Sand, viewed from the north east.

The building's principal elevation faces north east, where the land slopes down to meet the beach in the natural harbour of Sand Voe (Figures 2 and 3). At the time the house was built, the main approach to the house would have been by boat, hence the orientation of the building away from the more recently constructed road. The most exposed gable faces south east (Figure 4), taking the brunt of the prevailing weather, which can be extremely severe during the winter months, with gale force winds and persistent driving rain. Inside, the building has a simple plan, one room deep, with the principal rooms on the first floor, in the classical style (Figure 5). These reception rooms are handsomely panelled with moulded timber and have decorative plaster ceilings (Figure 6).

Figure 2: The open view to Sand Voe from the south east gable.

Figure 3: The location of Haa of Sand, on the western side of mainland Shetland.

Figure 4: The exposed south east facing gable, prior to works.

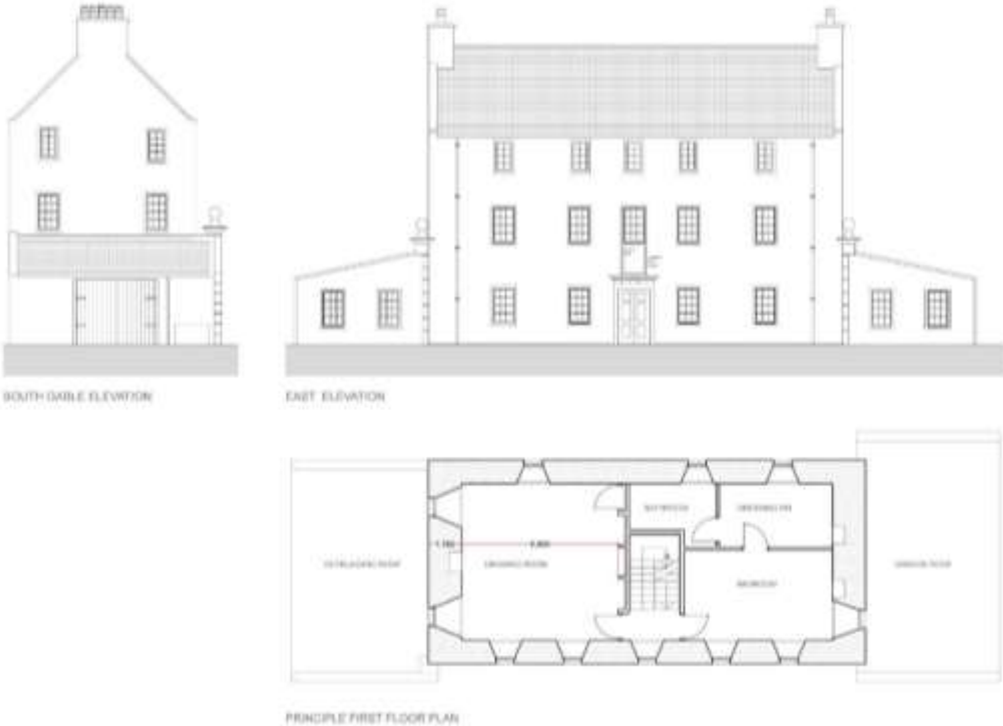

Figure 5: Plan and elevations of Haa of Sand (courtesy of Redman Sutherland Architects).

Figure 6: The panelled drawing room.

3. Project partners

The work was carried out as a collaborative project with Redman Sutherland Architects, the Shetland Amenity Trust and Historic Environment Scotland working together to develop proposals for the repair and adaptation of the building. Following completion of the site works, several Continuing Professional Development (CPD) sessions have been held in Shetland to share the knowledge and experience gained during the research and site work. This has helped to increase awareness of the history of external lime coatings in the Northern Isles, and promote the philosophy of conservative and authentic repair for traditional buildings. Lime Mortar Analysis was carried out by CMC Stirling Ltd, and Ian Tait of the Shetland Museum and Archives assisted with research into historic lime finishes.

4. Identifying defects

The owners of Haa of Sand sought advice in spring 2013 following a particularly harsh winter with constant south-easterly gales. They reported significant water ingress in various locations within the building, but most noticeably across the south gable at ground, first and second floor level. The water ingress was concentrated around the windows which were in poor condition (Figure 7), but also evident at higher level. The decorative timber panelling in the drawing room was becoming stained and warped in places, and water damage was visible in the cornicing in the bedrooms and at the window soffits (Figure 8 and 9). Water ingress was evident around the window reveals in several rooms as drips and leaks.

Figure 7: Water penetration around windows during bad weather (Photo: Redman Sutherland Architects).

Figure 8: Water damage to panelling and cornice.

Figure 9: Water damage to window soffits.

It was accepted that the windows were in a poor condition, and needed replacing, however an initial inspection by the architect identified other defects which suggested that the defective windows were not the sole or primary cause of the problem.

Roughcast

The roughcast to the south gable, which appeared to be a cement based mix, was cracked and bossed in several places. It had been patch repaired with a harder mix, and cracks filled with a silicone type sealant (Figure 10).

Figure 10: The existing cement-based roughcast was in poor condition.

Stonework
The lintols above the windows were cracked and damaged, the pointing was degraded and the window surrounds were badly eroded in places. Open joints at the skews were allowing water to penetrate the gable wall. Internal inspection behind the timber panelling at the window soffits showed that the external wall was cracked in places and had voids where mortar or masonry had deteriorated.

Chimneys and flues
Only one flue remained in use in the south gable, servicing the open fire to the first floor drawing room. The other flues routed to uncapped chimneys, which were leaking and poorly ventilated. The chimney itself was in poor condition; the cope stone was constructed of rough concrete, which had degraded to expose a pebbly aggregate (Figure 11). The chimney pots were cracked and damaged in places, and the haunching around the chimney pots was detached or missing in places.

Figure 11: Degraded and defective concrete chimney cope.

Roof flashing and abutments
The lead abutment at the junction of the gable and lean-to roof was poorly detailed and inadequate, as was the flashing between the roof and skews. At the skew copes there were open joints allowing water to penetrate into the wall. Some of these areas showed evidence of previous attempts to remedy the problem. The roughcast and stonework had been filled with silicone sealant; the stonework had been filled and plastered and the rotten windows had been repeatedly painted over.

5. Options appraisal

While it had already been accepted that the windows needed replacing, and the installation of timber double-glazed units was approved by the local planning authority, the options for the south gable were less straightforward. Removing the existing roughcast, and re-finishing the masonry with a slaister point (to match the front and rear elevations) was not considered suitable. The gable had been covered in the past to deal with the driving rain suggesting that a less robust finish would give inadequate protection.

The standard conservation solution would probably have been to remove the cement based roughcast, repoint and harl with a lime-based mortar, typically based on a dry hydrate natural hydraulic lime (NHL). However, recent failures of this type of lime harling in exposed locations in Shetland suggested that it may not be the best material. The architect was reluctant to advise the client to proceed with this expensive solution without further technical advice.

The architects therefore contacted HES Technical Research Team for guidance. The project and the type of building fitted well with team's current focus on climate change adaptation for traditional buildings and hot-mixed lime mortars research. The advice given was; as well as obvious repairs to defective elements, the detailing at the chimney and cope required upgrading to improve the resilience of the building and improve water run-off. It was agreed that removal of the cement roughcast and replacement with a lime harling was appropriate, but that a more traditional finish using a hot-mixed lime mortar may be more effective and authentic than the modern three-coat harl method. It was agreed that HES would provide funding to assist with these repairs, under the climate change adaptation and hot-mixed mortars research programmes.

The Shetland Amenity Trust, who are a grant-awarding body as well as project managers and contractors, were brought on board by the design team to advise and carry out the proposed work. The Trust awarded additional grant funding support for the work, demonstrating the commitment to repairing and maintaining traditional buildings in Shetland, and supporting traditional skills training.

6. Lime finishes in Shetland

The approach taken to specifying the re-harling work was informed by research into the existing historic lime finishes in Shetland, including documentary research (Tait, 2012), site inspections and lime mortar analysis. The evidence suggested that traditionally, buildings in Shetland were not routinely harled and lime washed, but finished instead with a relatively thin slaister harl, using lime-rich mortars and local aggregate (Figure 12).

Figure 12: Brae House, Shetland, where the historic lime-based harl survives.

This is in contrast to parts of the Scottish mainland where harling and lime washing was a traditional and effective weatherproofing finish. Concern had been raised in recent years by the local authority, and others, that the traditional vernacular style of buildings in Shetland was being displaced by the specification of harled and limewashed finishes to some notable historic buildings. Moreover, the finish specified for some recent projects tended to be a three-coat system based on natural hydraulic lime mortars or *formulated lime* mortars, often with added pigment to give colour, which was resulting in a rather 'Scottish central-belt' aesthetic. This was in contrast to the more austere weathered browns and greys that survived on older buildings, a result of the use of thin lime harling and local beach aggregate, moderated by decades of weathering in the unforgiving Shetland climate.

With this in mind, it was agreed that the gable wall should be re-harled using a one-coat, thin harl (maximum thickness of 10mm) and the mix should replicate as far as possible traditional Shetland harling, examples of which could still be found surviving well on buildings nearby. The aim was to test whether a traditional lime-based harling, appropriately specified, could still work effectively in exposed locations in Shetland, and that the character and appearance of the building need not be compromised by such an approach.

7. Mortar analysis

In advance of preparing a specification, several samples of mortar were sent for analysis (Figures 13 and 14) by CMC Stirling Ltd. The samples were taken from the existing cement based roughcast on the west gable of Haa of Sand, a sample from an adjacent area of walling, and three samples taken from other historic buildings in the area:

Sample	Comments
Haa of Sand existing roughcast	Analysis showed cement based material.
Brae House (c.1810) harling	Analysis showed relatively soft, lime rich harling, probably prepared as a hot mix, using local beach sand and added peat ash.
Grobsness (ruin,19th C)	Analysis showed relatively soft, lime rich harling, probably prepared as a hot mix, using local beach sand and added peat ash.
St Olaf's Church, Voe (18th C)	Analysis showed relatively soft, lime rich harling, probably prepared as a hot mix, using local beach sand and added peat ash.

Following the analysis, a specification was prepared for the lime harling finish, based on a gauged NHL and quicklime binder, hot-mixed with local beach aggregate (Figure 15). Whilst the removal of sand or aggregate from the foreshore is not permitted, the owner of Haa of Sand fortuitously had access to a sea-loch on the estate, and crofting rights to remove small amounts of materials for use on the croft itself. It is recognised that this is not a solution that can be generally replicated, and therefore an alternative mix using a carefully graded commercial aggregate, based on crushed granite sand and shell was also approved.

Figure 13: Traces of original lime-mortar finish attached to later roughcast.

Figure 14: Oyster shell pinnings in the original underlying mortar mix.

Figure 15: Sand and aggregate from the beach similar to that present in the original harl.

8. Re-harling

The existing cement roughcast was carefully removed by hand, to avoid damage to the dressed stone finishes and underlying masonry. The cement came away relatively easily in this way, with some of the bossed areas readily coming away in sections. A number of sample panels were prepared for the replacement harled finish, and applied onto an exposed section of gable wall within the lean-to shed. A range of mixes were trialled with varying ratios and strengths of Natural Hydraulic Lime (NHL) and quick-lime, different lime suppliers and different aggregate sources. The first mix trialled was a gauged mix of Otterbein 3.5 with quicklime and crushed granite sand. This mix was slow to take a set, and a range of subsequent mixes were sampled, varying the proportions of the quicklime and hydraulic lime, the strength and supplier of NHL, and the method of mixing. Some poorly performing samples were attributed to excess water added during mixing and poorly graded aggregate.

The most effective and visually appropriate mix was found to be:

10 Loch aggregate
2 Quicklime
1 NHL 5
1 riddled crushed seashell

An alternative mix with the same proportions but using crushed granite sand was also ‘approved’; on the basis that an alternative commercially available specification was desirable, to allow replication on other sites if required. The approved mixes were selected on the basis that they were straightforward to prepare in a consistent way, had a good, pliable and sticky consistency, adhered well to the substrate, and ‘went off’ well. The scraped surface (indicative of a weathered finish) was a good match in terms of colour and aggregate with existing historic lime mortars from the Haa and nearby buildings.

The specification was to repair and flush point the wall using a ‘hot-mix’, with the mortar used well-mixed and slaked in a forced action mixer and hand cast (harled) while still warm. The wall was flush repointed and given a harled finish with one coat to an overall depth of around 10mm.

The work to the gable was carried out in October/November 2014 (Figures 16 – 18) and the lime work kept protected with hessian and a sheeted scaffold. Whilst less than ideal in terms of timing for lime-work, the local advice was that the risk of frost was not high; the main weather risk being the gale force winds which are characteristic of a Shetland winter. For this reason it was not safe to keep the protective scaffold up after the masonry work was complete.

Figure 16: Work on site October 2014. The lime work was protected with plastic sheeting during works to prevent rapid drying.

Figure 17: Removing the cement roughcast using hand-tools (Photo: Redman Sutherland Architects).

Figure 18. Re-harling the gable and chimney.

9. Climate Change Adaptation

The re-harling work to the gable was the main focus of this project, but the opportunity was taken at the same time to make improvements to the detailing of the gable to increase the resilience of the building to current and expected changes in climate, namely the predicted increase in rainfall, driving rain and storm events. There was a particular focus on ensuring water could be effectively shed from the masonry, by improving and enhancing weathering details.

Chimney repair

Upon inspection of the chimney, it was noted that the chimney cope was constructed of rough cast concrete, with large pebbly aggregate. The concrete had begun to disaggregate, allowing water to penetrate. The copes were replaced with a new sandstone chimney cope, with improved weathering and drip details (Figure 19).

Figure 19: New stone chimney copes.

Limewashing

Following completion of the harling and other adaptation works, the south gable was limewashed, including the window margins and skews, with two coats of limewash, prepared using a gauged mix of quicklime and NHL 5. There is no evidence that Haa of Sand has been limewashed in the past, nor is there convincing evidence of a tradition of limewashing buildings in this part of Shetland generally. Due to the porosity of the weathered stone in some areas of the skews margins, and the relative vulnerability of the freshly applied harling, coupled with a completion date late in the year (November); it was agreed that to best protect the building from the impending Shetland winter, several coats of limewash was technically advisable and would not irreversibly harm the character or appearance of the building.

Skews and copes

The roof of Haa of Sand had been replaced, and is of relatively modern pitched slated construction, however the stone gables are contemporary with the earlier phase of the building, and had weathered considerably. The stone skew copes and decorative scrolled skewputts contribute significantly to the character of what is otherwise a relatively unadorned building externally, therefore alterations to this element were not desirable, despite the fact that the stone was heavily weathered. For this reason the skew copes were simply repointed with hot-mixed lime mortar and limewashed (Figure 20).

Figure 20: Limewashed decorative skewputt detail.

Windows

The windows throughout the property were timber, single-glazed sash-and-case style, generally in poor condition. Some had been replaced in the 1980s and most of these were rotten in places and allowing water ingress. As a separate phase of the project, listed building consent was obtained for replacing the rotten windows with new timber-framed, slim profile double glazed sash and case units. This work was carried out as part of the overall project but was not funded as part of the research.

Figure 21: New slim profile double-glazed windows in situ.

10. Moisture monitoring

Prior to undertaking the repair and adaptation works, HES Science team carried out moisture monitoring. Small ‘iButton’ temperature and RH monitors were placed in the voids beneath the window sills, where the external gable wall is thinner due to the window opening, and more vulnerable to penetrating damp. These were left in place for 12 months to monitor pre- and post- intervention conditions. In addition, microwave moisture monitoring was carried out across the gable wall. This non-invasive technique allows liquid water levels to be identified at depth within the wall core. A graphic interpretation can be generated which illustrates levels of dampness across the wall (Figures 22 and 23).

The walls were re-surveyed two years after the intervention; the interior finishes show no sign of dampness and the occupant reports that the gable wall rooms are dry with no evident issues of penetrating damp. However, moisture monitoring within the wall (at 3cm and 30cm depth) shows only modest improvements in moisture levels. This may be attributed to the length of time required to dry out saturated walls in an intermittently occupied building. The post intervention inspection nevertheless indicates that the gable wall is now coping adequately with the driving rain, in a way it previously was not. Monitoring is ongoing to determine the long-term impact and success of the interventions.

Figures 22 and 23: Pre-intervention moisture patterns within the gable at a depth of 30cm into the wall. The darker areas indicate high levels of damp.

11. Listed Building Consent

The majority of the work undertaken at Haa of Sand was like-for-like repair, however due to the alterations to the chimney detailing, and the change in appearance resulting from the re-harling and limewashing, a Listed Building Consent application was submitted. This was approved, as was a separate application for replacing the single glazed windows with double-glazed timber sash and case windows, as these were deemed to be beyond repair. Despite the initially startling change in appearance occasioned by the fresh application of limewash to the gable, it is debateable whether the character and appearance of the building has been adversely affected. Research into external lime coatings on Shetland by Ian Tait of the Shetland Amenity Trust suggests that buildings in Shetland may well have been lime-harled, giving a bright white appearance on initial application. There is however less evidence of a tradition of limewashing. Despite this, the technical requirement for a robust weatherproof finish was on this occasion agreed to be sufficient justification for limewashing.

12. Conclusion

Haa of Sand is a high status historic building, in a spectacular location, and with fine internal finishes and an interesting history, but its basic construction is unremarkable. Indeed, it is typical of many thousands of traditionally constructed buildings in northern Scotland. Solid-walled masonry buildings of this type, with gable walls built against the prevailing weather, are vulnerable to penetrating damp caused by driving rain, particularly where voids within the wall from redundant flues are unused or unvented. Where heating patterns have changed, and maintenance has been overlooked, traditional buildings become increasingly vulnerable to penetrating damp and other defects. This case study demonstrates that despite the increased stress on traditional buildings caused by climate change, such buildings can be sensitively repaired and adapted using traditional materials and techniques, allowing them to continue to be inhabited comfortably, and demonstrate their inherent sustainability and resilience to climate change (Figures 24 and 25).

The work at Haa of Sand was carried out during October and November 2014. The site has been inspected since this date on a number of occasions, and most recently a high level inspection using a cherry-picker was undertaken in September 2016. The inspection showed that the harling was holding up extremely well after two years, showing no signs of degradation or detachment; with only one small area of limewash failure, at a vulnerable point below the SE skewputt.

Figures 24 and 25: The gable end before works (left) and after (right).

References

Shetland's Vernacular Buildings 1600-1900, Ian Tait, The Shetland Times Ltd, 2012.

Further Reading

INFORM *Hot-mixed Mortars*
INFORM *Lime and Cement in Traditional Buildings*
Short Guide 6 *Lime mortars in Traditional buildings*
Short Guide 11 *Climate Change Adaptation for Traditional Buildings*

Historic Environment Scotland has also commissioned a series of new Technical Papers on hot-mixed lime mortars. These will be made freely available to download from our website:

Technical Paper 25: Historic lime renders and finishes in Scotland; Tom Addyman & Tim Meek
Technical Paper 26: Hot-mix lime work in Scotland 1990 – 2015; Craig Frew & Bill Revie
Technical Paper 27: Historic texts relating to hot-mix mortars in Europe 1400 – 1900; Nigel Copsey
Technical Paper 28: Specifying modern hot mixed mortar mixes; Roz Artis
Technical Paper 29: Hot mixed lime mortars – Considerations on micro-structure and performance; David Wiggins

Refurbishment Case Studies

This series details practical applications concerning the conservation, repair and upgrade of traditional structures. The Refurbishment Case Studies seek to show good practice in building conservation; some describe projects supported by Historic Environment Scotland, and some are entirely privately resourced projects. The results of some of this work are part of the evidence base that informs our technical guidance. At the time of publication there are 25 case studies covering measures such as repairs to masonry, upgrades to windows, walls and roof spaces in a range of traditional building types such as tenements, cottages and public buildings.
All the Refurbishment Case Studies are free to download and available from the HES website ***https://www.historicenvironment.scot/refurbishment-case-studies/***

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Our Technical Papers series disseminate the results of research carried out or commissioned by Historic Environment Scotland, mostly related to improving energy efficiency in traditional buildings. At the time of publication the series has 23 titles covering topics such as thermal performance of traditional windows, U-values and traditional buildings, keeping warm in a cool house, and slim-profile double-glazing.
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