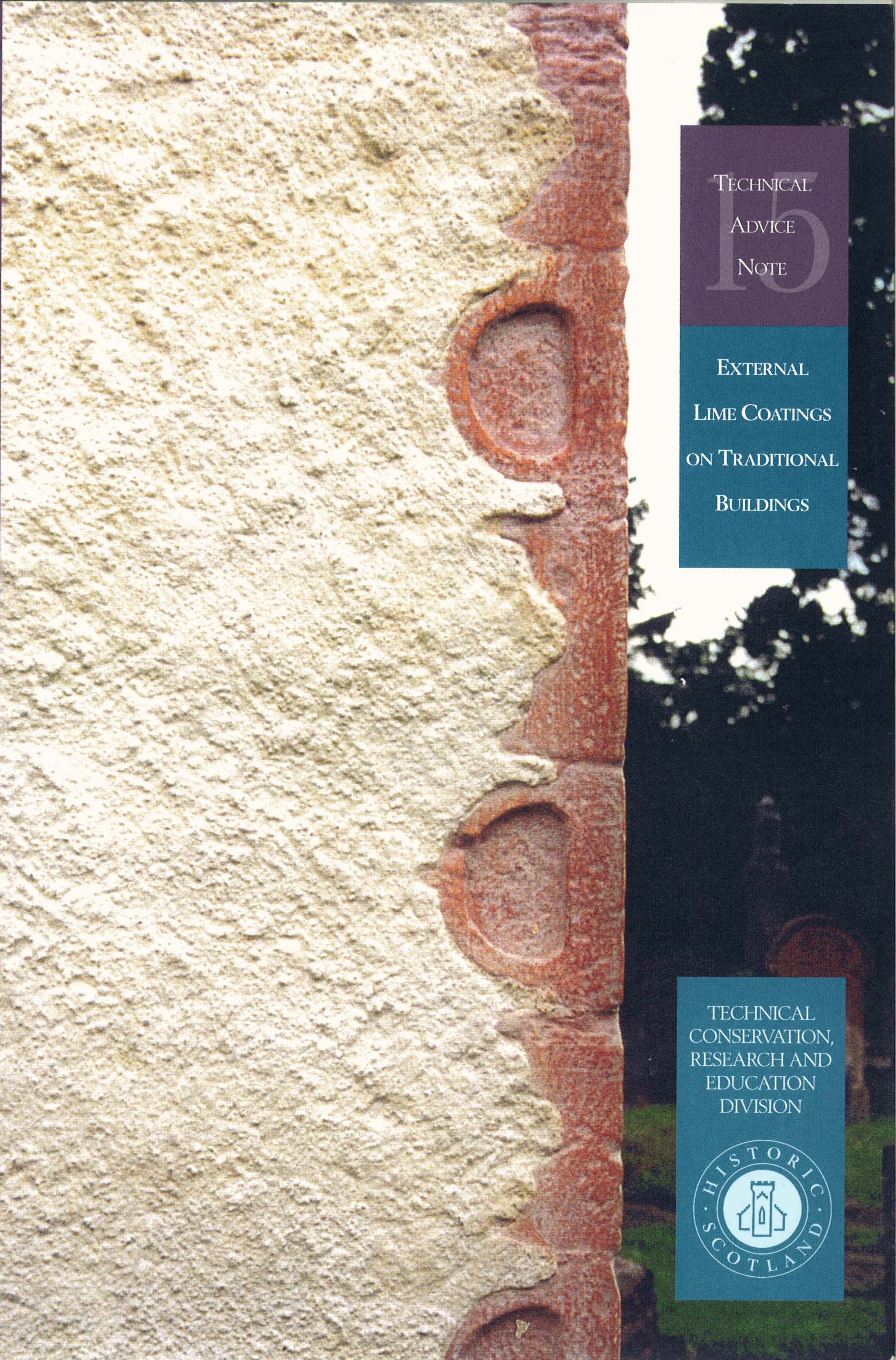
TAN 15



Technical Advice Note 15

External Lime Coatings on Traditional Buildings

Technical Conservation, Research and Education Division

Historic Scotland

Historic Scotland Technical Advice Notes

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TECHNICAL

ADVICE

NOTE

EXTERNAL LIME COATINGS ON TRADITIONAL BUILDINGS

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All other illustrations prepared by the authors.

FOREWORD

The publication of this Technical Advice Note (TAN), specifically dealing with lime based external finishing of buildings, continues the development of published guidance from TCRE that aims to improve knowledge and understanding of traditional building practices. It is intended to inform the re-awakening interest in the use of lime in building conservation work.

Advice on lime mortars is available in Historic Scotland Technical Advice Note 1, *'Preparation and use of lime mortars'*. In this complementary Technical Advice Note, information on the technology of lime is expanded with particular reference to external lime coatings, such as harling and rendering. The materials used are essentially the same. The wide range of surface finishes that can be found, from traditional thrown harl to the more 'polite' lined-out smooth floated render, are described.

The document builds upon comments received in consequence of publishing *'Case Studies of Traditional Lime Harling: A Discussion Document'* in 1996, and in the light of recent case studies where a number of external lime coatings failed to perform as expected. As TAN 15, it has been published out of sequence to enable the Scottish Lime Centre to take these emerging issues fully into account in its drafting.

The replacement of a life-expired lime harling on an otherwise sound old building can be a relatively straightforward operation, relying on the use of appropriate good quality materials and good site practices. These materials and practices are described in this TAN.

However, damage to traditional masonry buildings as a result of inappropriate repairs is now a widespread problem. The search for permanent, 'maintenance free' treatments during the second half of the twentieth century has left a legacy of accelerated decay in stone surfaces. These decayed surfaces present significant repair problems that cannot be fully resolved by the use of modern, or traditional, materials and techniques. When applied over damaged substrates, both modern and traditional coatings may be subject to mechanisms such as salt crystallisation and loss of bond. This TAN also discusses the implications and possible repair strategies for damaged wall surfaces prior to the application of lime mortar coatings.

In Scotland external lime coatings are found on clay or earth buildings, as well as masonry and brick structures. Although references in this TAN are primarily to masonry backgrounds, the basic principles apply also to the application of lime coatings to clay surfaces. More detailed advice on the treatment of clay and earthen buildings is contained in TAN 6.

The intention of this publication has been to provide a detailed introduction to the subject of external lime based coatings in Scotland. It is hoped that this will assist all those involved in the repair of traditional buildings - including owners, professional advisers, and building practitioners - in considering the need for, and approach to, carrying out appropriate repair work.

Ingval Maxwell
Director TCRE Division
Historic Scotland

Edinburgh
November 2001

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SUMMARY

This Technical Advice Note begins with a definition of what is meant by an external lime coating, within the wider context of the use of lime in traditional building construction. This is compared and contrasted with the common modern application of potentially damaging cement-based coatings to traditional masonry, or clay, buildings.

Each situation will be different, requiring a particular approach, and for this reason the provision of model specifications is avoided. General guidance is given on a range of matters in the order in which they might be encountered. Firstly, on the need for investigation of existing problems before decisions are made on the treatment to be carried out. This is followed by guidance on the selection of appropriate materials compatible with the existing building fabric, and on the use of good site practices in the production and application of the selected finishes. The need for adequate preparation and repair of masonry walls, onto which lime coatings will be applied, is emphasised. A further section covers the preparation and use of limewash, which is commonly associated with surfaces that have been coated with lime harling or render, and with whose use it shares many common technical requirements. This is followed by a brief section on specifying external lime-based coatings.

Appendices deal with a range of associated information, including a comprehensive glossary of the terms used, and a bibliography for further reading.

The need for an understanding of the principles of building conservation and a sound, practice-based, knowledge of the use of lime, remain the essential starting points for high quality work.

Fig. 1 Skail House, Orkney.
'Roughcasting or harling as they call it in Scotland is a mode of outside finishing well calculated to protect walls from the weather.'
(Loudon, 1853)

Fig. 2 Wardlaw Mausoleum.

Fig. 3 Charlestown Workshop at the Scottish Lime Centre. Limewash on sandstone and new lime harling. These materials were produced by burning and slaking local limestone.

1. INTRODUCTION

1.1 Definition of external lime coatings.

Exterior lime coatings for buildings are most commonly divided according to their application, into thrown materials (harling and roughcast), and materials applied by trowel or float (render, plaster or stucco). Although not traditionally a Scottish usage, the term *render* is sometimes used in an all-embracing way to describe all types of applied coatings. In practice, a range of surface finishes may be achieved irrespective of the means of application of the coating.

Lime mortar was traditionally the principal material used in Scotland for external harls or flat coatings. The mortar was a simple mixture of slaked lime and aggregates, sometimes with the addition of hair. In vernacular building, clay was also used for external coatings, on its own or in combination with lime. The development of other mortar materials in the nineteenth century has also left us with buildings coated in early forms of cement, for which various recipes were patented. This Technical Advice Note deals primarily with the use of lime mortars for external coatings.

Throughout the text, where reference is made to a 'mortar', this term may be deemed to include the complete range of mixes involving traditional binding and coating materials that are used in the application of surface coatings to walls. The materials for building, pointing and surface coating with lime are essentially the same, although they may be prepared and used in different ways. Where possible the use of the term 'render' has been avoided as this is now more commonly understood as a coating of cementitious material.

1.2 The function of lime coatings.

'Outside plastering includes stuccoing with the different kinds of cement; roughcasting Scotch and English; and common lime and hair plastering, ornamental or otherwise. The principal purpose for which any of these processes is adopted on the outside wall of a cottage is, to keep them dry; and a second purpose is, to render them ornamental, either by imitating stone, or by producing a surface more curious or agreeable to the eye, than the rude materials concealed behind it.'* (Loudon, 1853)

* In this context 'cement' refers to materials with a hydraulic set, i.e. hydraulic lime.

1.2.1 A protective coating.

The widespread use of lime in the past was due to the material's excellent weatherproofing abilities. Lime as a method of finishing walls provides a sophisticated mechanism for dealing with complex movements of moisture that affect the fabric of buildings. A well constructed and well maintained traditional, lime-finished building will provide dry, warm and comfortable accommodation.

The reinstatement of external lime coatings to a traditional masonry building has the potential to improve weatherproofing and thermal insulation and also to reduce problems of stone decay.

Where lime mortar coatings have been lost from an otherwise sound and well maintained building, their reinstatement can be relatively straightforward. Unfortunately, however, there are many situations where the building itself presents problems, often due to the previous use of incompatible materials in twentieth century repairs. In many instances the stimuli for replacing an external lime coating on a traditional building are those of water penetration and/or surface decay of the stonework.

In the case of water penetration, measures can normally be taken to repair or improve building detailing and, provided the surface of the masonry itself is sound, an appropriate lime mortar coating should be capable of eliminating direct water penetration through the wall. Permeable lime based coatings will assist in preventing water penetration and reducing moisture levels in the masonry by allowing the building fabric to breath. On the other hand the application of strong, relatively impervious coatings, or of film-forming materials, normally serves to retain moisture in the fabric and exacerbate the underlying decay, leading to increased risks of dampness and associated timber decay and, in due course, rejection of the coating.

When used over significantly damaged stone surfaces, lime mortar coatings can also protect the underlying stone from further decay, but may themselves require ongoing maintenance to ensure the effectiveness of this protection. Where the wall fabric is suffering significant surface decay, problems may be presented that compromise the application and durability of any type of new mortar coating (whether lime- or cement-based).

1.2.2 A decorative coating.

Lime coatings conceal the *'rude materials'* of construction and fulfil a decorative function as part of the architecture of the building. The frequency with which exterior coatings were used in the past is generally underestimated. The widely perceived character of Scottish architecture as one of stone is a relatively recent fashion, of nineteenth century origin, when romantic sensibilities celebrated ruins, stripped away harls and renders (or failed to renew them) and developed an aesthetic of exposed stone for much of architecture thereafter.

A lime mortar surface coating creates a plain surface against which the form and detail of the building's architecture can be understood. Removing lime coatings, or revealing features once hidden, alters the appearance and distorts the architectural expression of the building, and it will also affect the way in which the building functions technically.

To appreciate the original character of lime-finished buildings, and the regional variations that exist, one must consider how traditional coatings were applied, and the various finishes that might be achieved.

1.3 The character of lime coatings.

1.3.1 Lime harling.

The best known type of lime mortar coating in Scotland is the traditional harl. It frequently has an open textured surface giving a 'vernacular' finish to the building, although a range of more 'polite' finishes are possible by re-working the material once on the wall to achieve closed textures and more level surfaces that can resemble ashlar stone.

Historically, the choice of lime and aggregates gave character to the finish and these would usually have been found locally. Aggregates were drawn from a sand pit, riverbed or beach (often including a proportion of shell), or were a local earth deposit. Larger pebbles and materials such as coal and brick are often found in old lime harling materials, and may have been incidental components of the lime and sand, or may have been deliberately added to the mix.

Harling is applied by casting a fluid lime mortar onto a wall and, from examination of surviving lime harls, appears often to have been applied quite thinly in one or two coats. Following the removal of any existing defective material it may be necessary to repair the wall before re-application of the harling. Damaged or uneven rubble-built walls may require to be brought out to the required profile of the finished work by building out the whole wall surface to match the character of the original masonry and to achieve a relatively level plane onto which harling can be applied. A suitable surface for the application of harling was traditionally achieved by pointing up the masonry, using small pinning stones to pack out wider joints and voids.

Scottish harling differs from the English way of *roughcasting*, and from the methods adopted to apply modern cement-based harling. Modern building

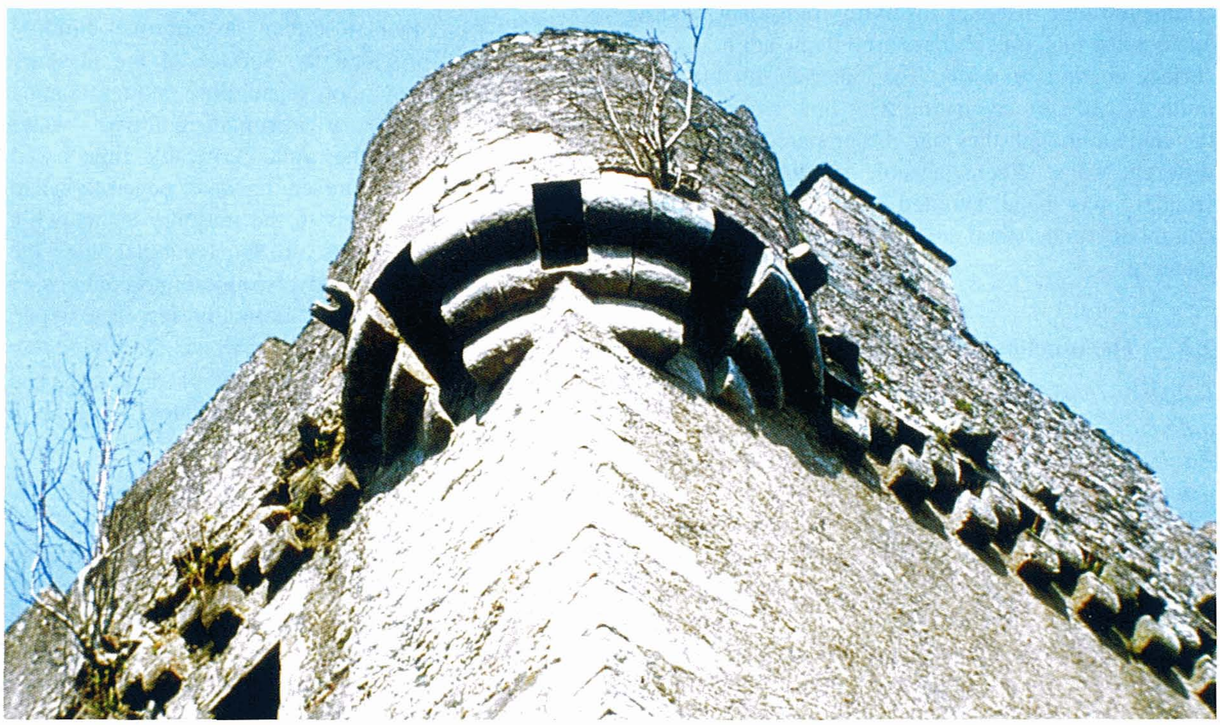


Fig. 4 Original harling.

Fig. 5
'On the outside they fill up the interstices by driving in flat stones of a small size, and in the end, face the work all over with mortar thrown against it with a trowel, which they call harling'.
(North of Scotland 1754: Dictionary of the Scottish Language Vol. II p.536)

techniques involve the application of one or two undercoats by trowel, followed by casting-on a top coat of wet-dash (a slurry of lime or cement and aggregate), or a dry-dash (a uniform aggregate such as pea gravel or crushed rock chippings). This method is not considered traditional to Scotland, but may occasionally be found.

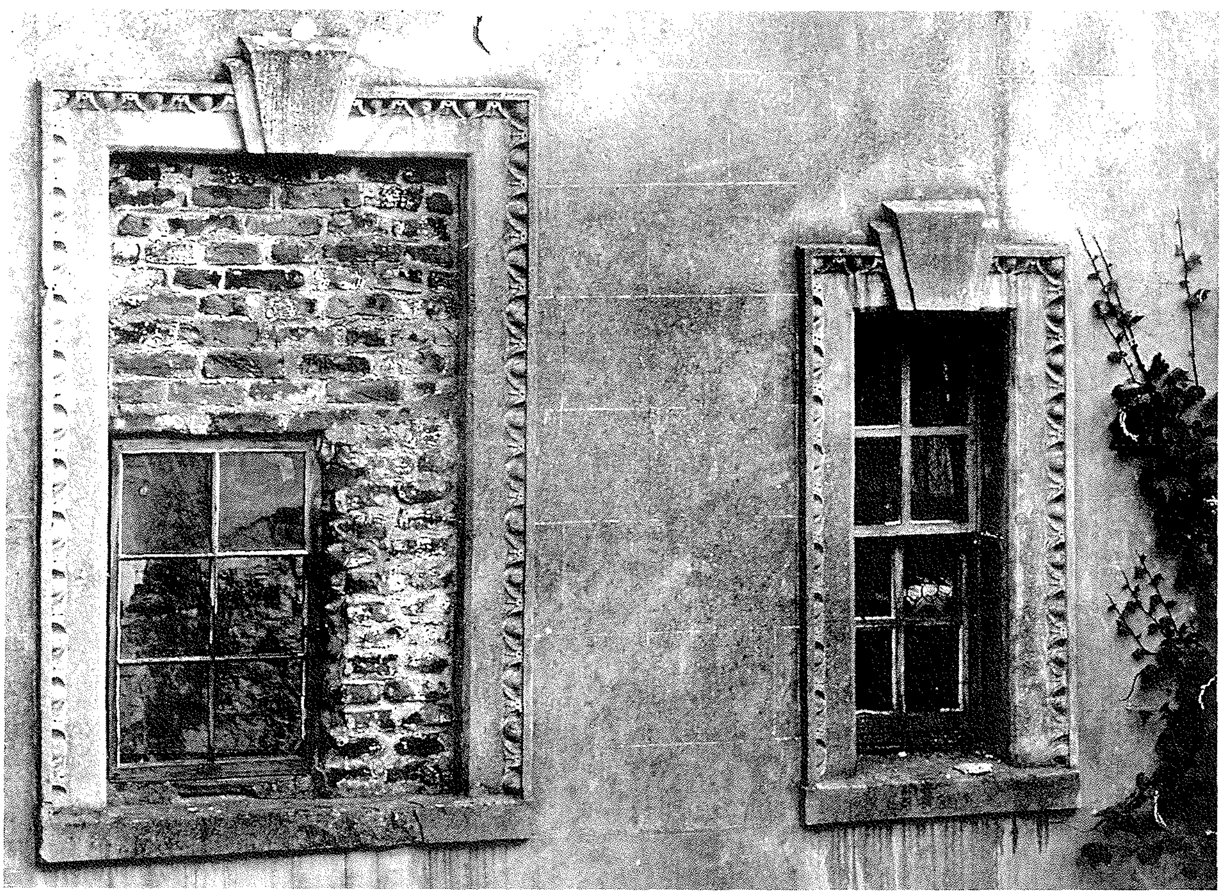
The late eighteenth century saw much experimentation in materials and methods, and a letter of 1761 in the Bute Papers entitled *'Directions for roughcasting stone walls in the new way'* describes a render applied by trowel with a thrown final coat of small pebbles coated in *'flour of lime and water'*.

Unless a float-applied coating is clearly original to a building, all new lime harling coats should be cast on. Casting on gives better adhesion and helps to avoid local variations in thicknesses over uneven wall surfaces.

1.3.2 Lime renders (or flat floated coatings) and 'polite' finishes.

A range of different finishes can be seen in surviving original coatings. Cast-on harls appear to have been most common but examples may be found of smoother lime finishes which were applied by pressing back a cast lime harling before setting occurred, to smooth out the surface, or of finishes that were applied by float.

Fig. 6 West front of Hedderwick House, Angus, before demolition.



Smooth render, sometimes known as stucco, is less common in vernacular building. It sometimes had 'lining-out' drawn onto the surface in imitation of ashlar blocks.

As flat finishes (or 'renders') became more common on many town buildings and country houses throughout Britain during the eighteenth and nineteenth centuries new materials were being developed, including hydraulic lime mortars, Roman cements, other patented cements such as Keene's cement, and mastic stuccoes. The extent to which such materials were used, and the frequency of occurrence of smoother finishes in Scotland is not well understood at present.

1.3.3 Modelled and decorative surfaces.

External coatings in Scotland are generally found to be quite plain, with little evidence of applied decoration when compared with finishes such as plaster pargetting in England and decorative renaissance plaster relief work found in parts of Europe. This is not to say, however, that more elaborate external finishes never existed, and any evidence which might be found for more decorative finishes should be carefully protected and recorded.

Fig. 7 Hedderwick House, 'Time'
A significant example of external decorative plasterwork is recorded in photographs of the Old House of Hedderwick, near Montrose (held in the National Monuments Records in Edinburgh). Now demolished, this house of c.1700 had a lined-out smooth lime render, mimicking fine ashlar, with plaster egg-and-dart moulded window architraves, and a high relief plaster sculpture.

1.3.4 Sneck harling.

Locally distinctive characteristics in surface finishes can derive from variations in the underlying construction, variations in methods of application and finishing, and from variations in the constituents of the mortar mixes used for surface coating.

A common surface finish in the north east of Scotland is sneck harling, which appears as a partial harling to the walls, with the faces of larger stones remaining uncovered. This type of finish may originally have been carried out by casting a coarse lime mortar into the hollows between rounded field boulders (which were used in construction during first stage agricultural improvements of the second half of the eighteenth century) or it might result from the partial weathering away of a full harl coating. The resultant appearance may thus be a function of the technology rather than a conscious design decision, although later examples of sneck harling may be a deliberate technique derived earlier traditions.

Fig. 8 Sneck harling, Banffshire.

Fig. 9 Limewash on stonework.

1.3.5 Limewash and colour.

Limewash is a traditional external and internal paint, and was commonly used as a final finish over lime mortar coatings. In some regions of Scotland limewash is applied directly onto stonework. The material comprises slaked lime and water, sometimes with the addition of pigment and other materials such as tallow, or casein (from milk).

Limewash has decorative and protective functions. With the addition of pigment, limewashes were a means of introducing colour to buildings. Traditional pigments were ochres, earths and clays naturally coloured by iron oxide. Other colouring agents included mineral and vegetable pigments, lampblack or soot, the latter producing blue and grey colours. Copperas, or sulphate of iron, is a well-known traditional limewash colouring agent, found particularly in the Lothians, which can give a strong orange colour.

Limewash is usually applied as a simple one-colour wash but there are examples where limewashes (and other forms of paint) were used decoratively to pick out detail or to decorate façades.

The extent of colour use in Scotland is not fully understood, although local tradition and subsequent regional variation would be expected. Colour appears to have been used mostly in the main towns and villages of the east and west coastal fringes, but was less common in inland and Highland areas. *(C Hughes SVBWG 1981).*

1.4 The character of traditional masonry.

Traditional masonry structures were built as mass construction, generally without the application of impermeable finishes, and without the incorporation of membranes and damp-proof courses which modern construction employs. Most masonry materials and their binding mortars are porous and permeable to some degree, improving their ability to take in and release water, and water vapour.

1.4.1 The effects of moisture on walls.

Water cannot be totally excluded from traditional masonry building fabric, but traditional building materials can contribute to the disposal of undesirable moisture through evaporation, and lime coating materials play a vital role in this process.

Fig. 10 Traditional masonry wall construction.

Lime mortar used as a coating material will exclude a certain amount of water but remains essentially porous and permeable, and excess water taken into the wall will evaporate again, when conditions allow. In a continuous cycle of wetting and drying, rainwater is retained mainly in the outer part of the wall and the lime coating layer, minimising water movement or retention, and associated deterioration, in the masonry itself. In severe conditions a mass of lime in the core of the wall can 'mop up' penetrating water and minimise the risk of penetration to the interior.

Any increase in moisture movement, or retention of moisture in the masonry, will increase the risk of salt crystallisation and resultant damage in the stone. Severe salt damage and crystal formation can often be observed in masonry exposed by detaching cement render. With the use of a lime mortar coating, moisture evaporation takes place at the external face of the coating and, although salt-induced decay may affect the lime coating in preference to the masonry itself, this coating is more easily renewed.

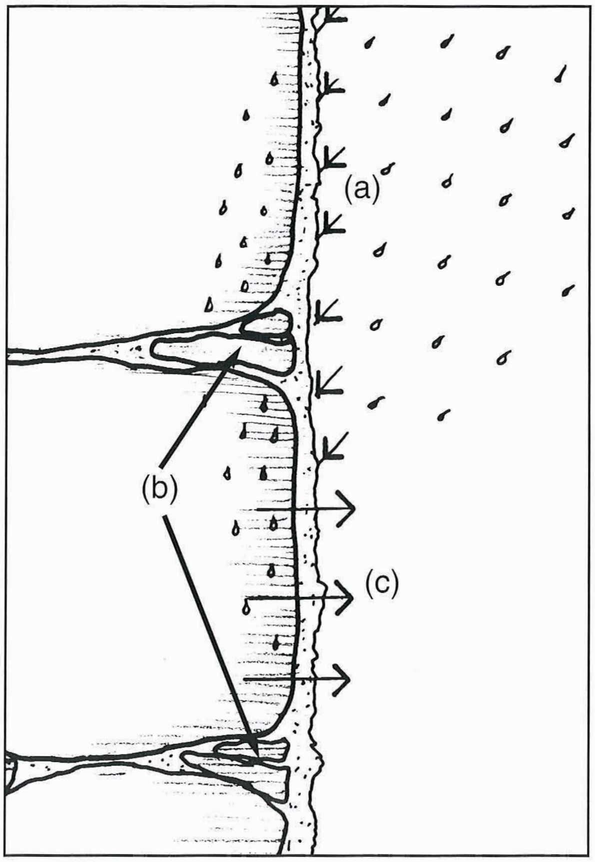


Fig. 11 Movement of moisture through external lime coatings.
Diagram A: Moisture may be absorbed by the coating but will then evaporate.
Key: (a) External sources of moisture, e.g. driven rain.
(b) Joints filled with lime mortar and pinnings.
(c) Moisture absorbed by mortar and stone is able to evaporate to the surface without being trapped.

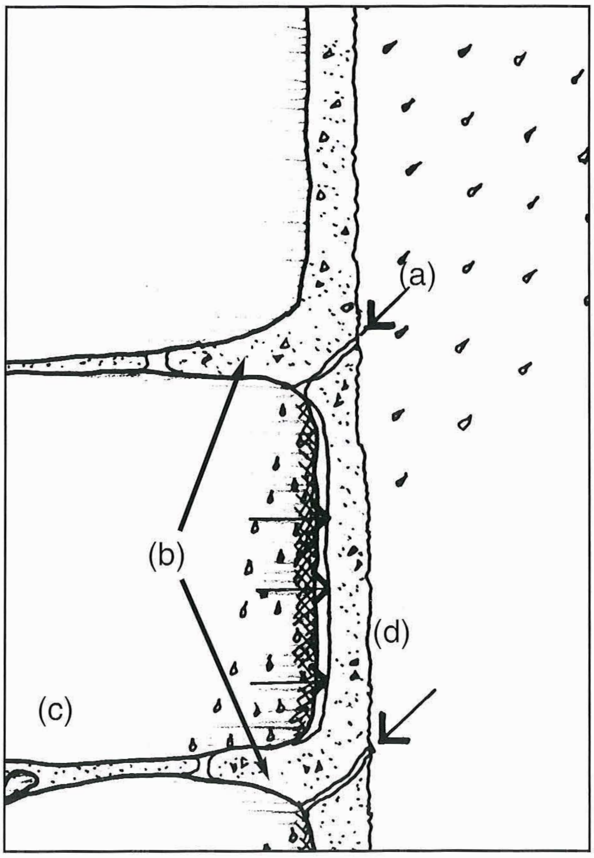


Fig. 12 Movement of moisture through cement based coatings.
Diagram B: Moisture enters through hairline cracks in otherwise impervious coatings and becomes trapped.
Key: (a) External sources of moisture.
(b) Joints raked out to provide key for cement coating.
(c) Moisture may be forced deep into the wall where harm may occur to internal finishes.
(d) Stone decays and render becomes detached.

1.5 The technology of lime coatings.

1.5.1 Lime or cement?

The use of lime-based external coatings on traditional mass wall masonry buildings is in sympathy with their construction. Importantly, the use of lime mortars, rather than modern materials, for the repair and finishing of such buildings has the potential to continue the technology of the porous 'breathing building'. This traditional form of construction encourages the re-evaporation of moisture absorbed by porous building fabric, such as sandstone and lime or clay-built structures.

Cement coatings, on the other hand, do not allow for the re-evaporation of moisture and, as a result, significant levels of moisture build-up, leading to the failure of the external coatings (by frost action) and considerable damage to sandstone masonry. Trapped moisture tends to migrate inwards, drying to the interior of the building, and can adversely affect timbers in contact with the masonry walls, encouraging the development of timber decay. Clay structures are likely to be totally destroyed over a period of time by the application of cement-based coatings.

In the twentieth century, traditional lime coatings have been re-interpreted using modern materials. Cement has so consistently replaced lime as the common ingredient for making mortars, that cement coatings are still being mistakenly specified as a 'like for like' replacement of original *lime* harl and render materials.

Cement and lime are not the same material, and it is recognised now that severe damage may be caused to traditional masonry buildings by the inappropriate use of cement-based coatings. In order to effect appropriate repairs to historic buildings it is essential to understand and respect the technology of traditional buildings.

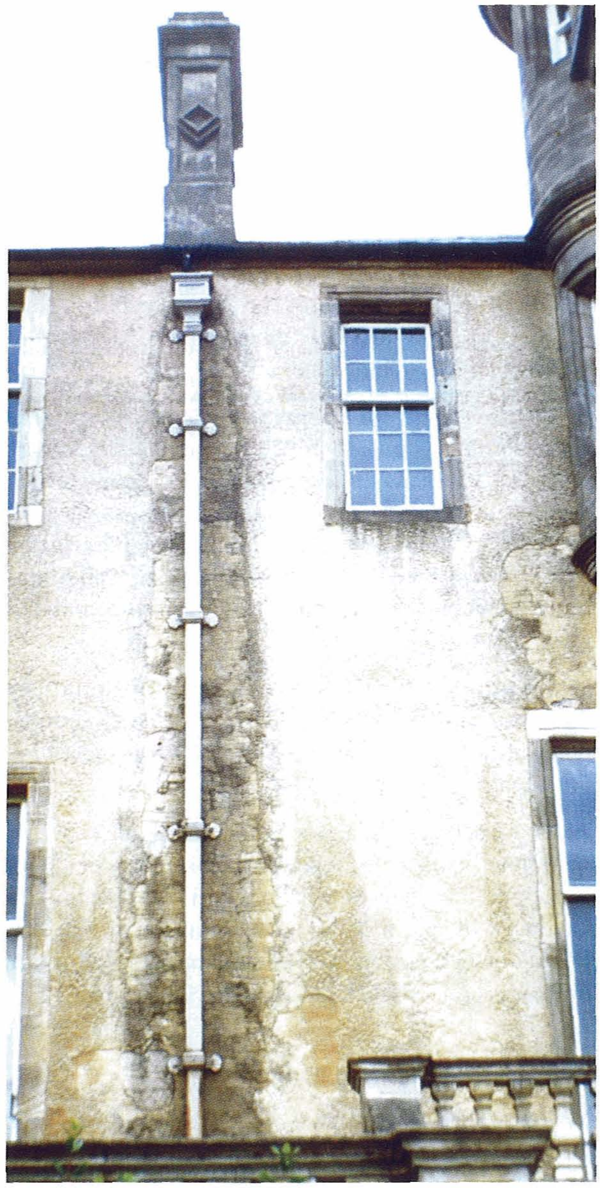


Fig. 13 Building defects highlighted by lime coatings.

1.5.2 Seasonal and structural movement.

Lime-based materials can accommodate small amounts of expansion and contraction without compromising the integrity of the material. External lime coatings may therefore accommodate the minor structural and seasonal movement, which is intrinsic to old buildings, without cracking.

1.5.3 Protection and repair of masonry.

Lime mortar is generally a weaker material than the host masonry, and will be sacrificial to it. The lime coatings will take the brunt of reactions such as frost action and salt crystallisation caused by moisture movement, in preference to the masonry. Lime materials thus have a finite life span, albeit potentially a relatively long one, requiring maintenance and eventual renewal. They are renewable at a lower cost and with less disruption to the building fabric than is required during the renewal of masonry. By responding more quickly to changes in their environment, lime materials will also serve to emphasise maintenance requirements in the building, that might have been superficially disguised by cementitious materials.

Reinstatement, or provision, of an external lime coating to decaying or damaged stonework provides the opportunity for sensitive repairs, with a minimum of disruption or loss of original fabric. Gentle infilling and patching can be undertaken without need for the cutting out and replacing of stone which is required in the repair of exposed masonry work.

1.5.4 The benefits of using limewash.

Limewash is usually applied as a final finish to a lime harling or flat 'render'. It has the same characteristics of permeability and breathability as other lime materials, making it a wholly compatible finish to a lime mortar coating.

The application of limewash also 'heals' the surface by flooding into any small cracks that may have formed. A limewash finish may also be described as 'self-healing', as lime can be dissolved and re-deposited in cracks over a period of time.

In some locations, for example in the presence of mild acidic rain, limewash finishes are self cleaning. Provided a sufficient thickness of limewash is present, the slight surface sulphation of limewash will continually wash clean. This can be observed in the city centre of Stockholm where limewashed buildings remain much cleaner than their acrylic painted neighbours.

Limewash is sacrificial to the host material, as described in 1.5.3 above, and will require periodic renewal in order to continue to protect the underlying lime coating.

A certain degree of colour variation should be expected with lime coatings and limewash. Uniformity of colour is not possible, and some natural variations will occur. Colours will appear darker or more intense while wet, or may sometimes become translucent, but will return to their original opaque colour when dry again.

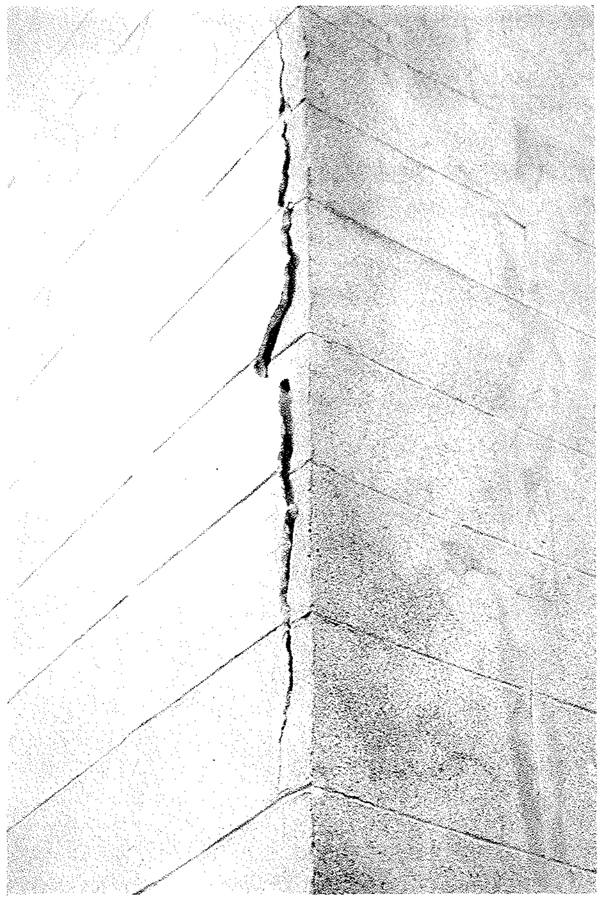


Fig. 14 Cracked modern portland cement render.

1.6 Modern coating materials.

Modern coating materials tend to be dense and impermeable, designed as a barrier for the exclusion of water. In practice, no modern coating on a traditional masonry structure can be completely waterproof. The strength of cement renders makes them brittle and inflexible, and any movement (structural, seasonal or drying shrinkage) causes some degree of cracking. Micro-cracks also occur as a result of drying and setting of the cement render. Water may be drawn by capillary action into the cracks and become trapped behind the impermeable render coat. Other faults, such as defective rainwater goods and wall-head cappings, will accelerate this process. The result can be severe deterioration of the masonry behind dense render, which characteristically becomes 'boss' or detached from the wall. Decay is mostly observed in the erosion of softer masonry, such as sandstone and brick, but buildings constructed of denser stones such as whin may be affected, as water may be drawn far into the wall thickness. A build-up of moisture in the building fabric is likely to encourage interior dampness and timber decay. If a dense external coating is used in conjunction with an impermeable interior plaster finish this mechanism can be extreme.

Dense cement renders, once affected by moisture penetration, tend to detach in sheets, often removing the face of the underlying masonry. Due to long term movement of minerals within sandstones, this 'skin' tends to form a protective face to the stone, leaving somewhat weakened underlying material below. In contrast, the natural weathering of lime-based materials is likely to be less destructive and more aesthetically acceptable, as materials respond to the effect of the weather and develop a 'patina of age'.

Many modern masonry paints, even when described as 'permeable', can trap moisture and contribute to the decay. Where they are in contact with dry, sound masonry these paints will bond to the masonry surface and can prove very difficult to remove. Where water or moisture vapour becomes trapped behind the surface, modern film-forming paints will crack and peel, becoming unsightly as they deteriorate.

1.7 Comparison of lime and cement practice.

As building technology has changed, the techniques of applying cement-based harling and render have diverged from traditional methods. Common modern practices, such as application by trowelled coat and dash coat, dubbing out with excessive thicknesses of mortar, removal or loss of pinning stones, and increased thickness of coats, are inappropriate for the application of lime based coatings.

Mechanical fixings have been developed for use in conjunction with cement coatings. These include expanded metal lathing, metal angle beads, and expansion joints, allowing thermal movement without cracking. Details such as these are unacceptable for work on historic buildings. Expansion joints will disrupt the 'architecture' of historic facades as they run arbitrarily across walls. Holes drilled for the attachment of lath would cause physical damage to historic masonry. The raking-out of joints and the loss of pinning stones, the stugging of masonry to form a key for the coating, as well as the use of chemical agents to improve the bond between applied finishes and the background, will also cause damage.

If properly worked, traditional coatings based on lime mortars do not have the inherent problems of shrinkage and rigidity of cement and therefore do not require the use of expansion joints or fixing details such as metal lath. They adhere to backgrounds by suction as the material dries out.

It is important not to confuse the technologies of lime and cement materials and not to mix incompatible materials and techniques. For example, lime-based coatings cannot be applied over a cement backing coat, or over silicone-treated masonry, as they will not perform adequately in such situations.

The use of traditional lime finishes on modern backgrounds might be considered where new work is added to an existing traditional building. With appropriate detailing and specification, such applications can successfully be carried out.

1.8 Good practice with lime coatings.

External lime coatings, appropriately specified, properly applied and well cured, will contribute positively to the overall performance and health of traditional, solid-wall masonry buildings and, given appropriate maintenance, will be durable. Conversely lime coatings may reflect and highlight bad detailing, faults in specification or quality of materials, poor workmanship, and lack of maintenance.

Site practice in the use of lime materials is more exacting than that commonly associated with cement materials, as lime based coatings will not tolerate shortcuts.

The 'maintenance free' and 'quick fix' ethos, which has permeated the building industry in modern times, cannot be applied to lime-based materials. External lime coatings may require more effort at the outset but will offer benefits in the long term protection they afford to historic masonry. The selection of suitably experienced contractors remains critical to the outcome of any project, but it should be remembered that, traditionally, lime was one of the commonest of building materials. It was used successfully without any scientific knowledge, but with due care and respect for its properties and with an understanding acquired through regular use.

For the majority of applications, attention to a few basic principles before, during and after work will minimise the risk of problems occurring. These include specifications appropriate to the job, careful preparation, selection of suitable good quality materials, correct methods of their application, and appropriate curing.

Ensuring good overall detailing, including the need to avoid introduction of inappropriate changes during repair work and, subsequently, conscientious maintenance of the building, are also essential factors in ensuring the longevity of external lime coatings.

1.9 The potential for problems to occur.

As highlighted in 1.8 above, the consequences of a lack of understanding and poor skills can result in early and often catastrophic failure of external lime coatings. The materials and practices described below will not tolerate either unrealistic expectations or poor site practice. It is particularly important to be aware of, and safeguard against, fluctuating environmental conditions. While work to some parts of a building may be successful, other adjacent parts may fail where, for example, frost has affected the mortar. Proper planning to provide adequate time for development of suitable specifications, procurement of the correct materials, appropriate programming and timing and for thorough and conscientious execution of the work is of paramount importance.

Those concerned with the specification, planning and carrying out of the work must all possess an appropriate level of awareness, knowledge and experience. Where these skills are not available specialist advice should be sought at an early stage.

Even with the best and most appropriate materials and the best site practice, there will be some problem buildings where the achievement of long term durability in a lime coating is not possible. The presence of significant salt contamination in masonry backgrounds may jeopardise lime-based coatings whilst, in the same location, stronger cementitious coatings will retain moisture and accelerate decay of the masonry itself. Although lime-based coatings in these difficult situations will be the most appropriate in terms of the ongoing health of the building, a regular routine of repair and maintenance may have to be accepted.

1.10 The need for listed building consent.

Where work involves the repair or alteration of existing historic buildings, the presumption should always be to repair surviving original materials. Lime finishes are almost always capable of continual repair. Any replacement work should include the use of matching materials and techniques in order to achieve a finish that is sympathetic to the character of adjacent surviving work.

Listed building consent is required for the demolition of a listed building, or its alteration or extension in any manner which would affect its character as a building of special architectural or historic interest. The replacement of a lime harling with a cement-based harling would normally be considered as affecting the character and appearance of the building.

Fig. 15 Traditional lime harling subject to salt attack on badly contaminated masonry.

2. MATERIALS

2.1 Introduction.

A range of materials is required for the successful repair or replacement of external lime coatings and, where necessary, of the underlying wall surface. The surviving existing materials should be studied to ensure appropriate materials and repair techniques are employed. Repair materials will include the following:-

- Those needed for the repair of the wall surface underlying the lime coating.
- The basic mortar materials, both for surface repair and or the coating itself.
- A selection of additional constituents that may be necessary to achieve a mix that matches the original or which provide the correct technical performance of the mortar.

Lime mortars for the surface coating of walls are made by mixing a binder (lime) with aggregate, and are used in a plastic or wet condition, which will harden to form the finished coating.

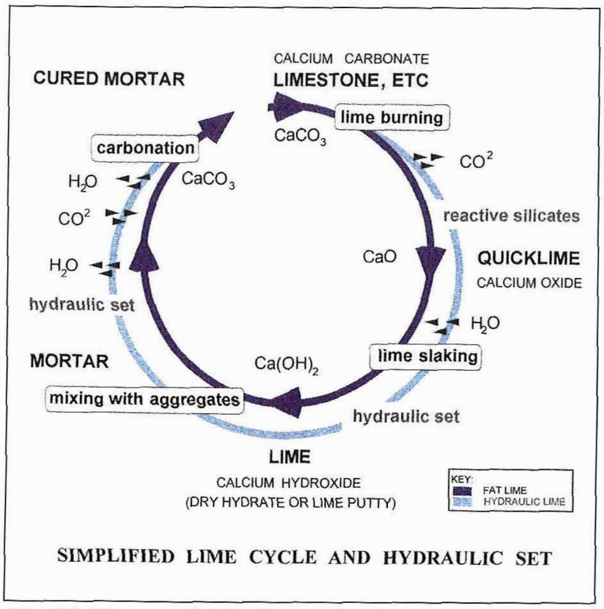


Fig. 16 Diagram C: The lime cycle, showing both fat lime and hydraulic lime processes.

Traditional mortars for construction and pointing, for harling, flat 'rendering' and plaster (and for limewash) are made of the same basic materials, but a range of different forms of lime and aggregates are used. The constituent materials will affect the properties of the mortar created and should be selected for the particular construction, condition and context of each building.

It is important to evaluate or analyse existing surviving material before selection of replacement mortars, to ensure the suitability of specified materials. This will often require microscopic or chemical analysis, by a suitable laboratory. Details of mortar analysis services are given in appendix H.

For more information on the technology and production of lime materials see Technical Advice Note 1 *'Preparation and Use of Lime Mortars'*. A summary of relevant information is included in this chapter.

2.1.1 The lime cycle.

The use of lime mortars in buildings is based on the chemical principle that calcium carbonate found in limestone, chalk, shell, and other naturally occurring materials, can be rendered, through the processes of burning and slaking, first into quicklime, then into hydrated lime. The hydrated lime may take the form of a dry powder or a putty. In the right conditions wet hydrated lime binder in a mortar will dry out slowly and absorb carbon dioxide from the air to reform calcium carbonate. The sequence of chemical changes involved is described in the 'lime cycle'.

2.1.2 Lime burning.

Limestone (calcium carbonate) is burned, or calcined, in a lime kiln, where carbon dioxide is driven off leaving *quicklime* (calcium oxide), which is highly reactive with water.

2.1.3 Lime slaking.

The controlled process of combining quicklime with water to form *slaked lime* (calcium hydroxide) is known as *slaking*. The reaction can be violent and creates high temperatures. Slaked lime is the material used as the basis of lime mortar, harls, renders and limewash. Slaking with an excess of water creates lime putty. Alternatively, quicklime may be slaked with a minimum quantity of water or with steam to produce a dry powder or *hydrate*.

2.1.4 Carbonation.

The slaked lime is normally combined with sand or aggregate to make a mortar. To complete the lime cycle, once the mortar is placed, the slaked lime reacts with carbon dioxide (from the air), losing its chemically-bound water molecules and reverting back to the stable material, calcium carbonate. This is known as *carbonation.*

2.2 Constituent materials of mortar.

There are various types of lime available for building, with different chemical compositions and properties. These can generally be classified as either pure non-hydraulic limes *(air limes)*, or as limes with varying degrees of hydraulic properties *(water limes)*.

Mortars made using non-hydraulic lime are generally more permeable and exhibit lower strength characteristics than those using hydraulic lime.

2.2.1 Non-hydraulic lime.

Non-hydraulic limes are derived from the purest limestones, which contain high proportions of calcium carbonate and do not contain clay or other reactive minerals. They are also known as *fat limes, high calcium limes* and *air-limes*. The term 'non-hydraulic' refers to the fact that the material will not set in water, but entirely by carbonation as described in the lime cycle.

For modern site practice, non-hydraulic lime is normally available as slaked lime putty, either on its own or already combined with aggregates to form a mortar. Methods of producing lime mortar are described in 2.4.

Non-hydraulic lime is also available in hydrated form, known as *builders' lime*. This material is much less reactive than lime putty and is normally only used as a component of modern cement/lime/sand mortars. It is not recommended as a basis for lime mortars for external coatings or for limewash.

2.2.2 Hydraulic lime.

Hydraulic limes differ from non-hydraulic limes in that the limestone they are derived from incorporates certain impurities. Clays and other reactive silicates or aluminates alter the characteristics of the mortar, giving the material an initial set in water (a quicker set), plus a greater degree of strength. The term 'hydraulic' refers to their ability to set in water. However, full strength will still be achieved in hydraulic mortars by slow carbonation in air.

Natural hydraulic limes are traditionally classified in strength as being either *feebly*, *moderately* or *eminently* hydraulic. The relevant European standard classifications described in BS EN 459-1: 1998 are NHL2, NHL3.5 and NHL5. The extent of overlap between these categories is significant and it is normally recommended that hydraulic limes should be selected on the basis of known performance of material from specific sources.

Because they will set in water, moderately and eminently hydraulic limes are generally supplied as a *dry hydrate* (i.e. lime that has been slaked to a powder). Some hydraulic limes are produced in the UK, and production is increasing but, in the meantime, most of those used are European. Hydraulic limes should be bought as fresh as possible, stored in dry conditions and used within 6 months of manufacture.

In principle, feebly hydraulic limes can be obtained in putty form, although none are currently commercially available in the UK. The putty will stiffen up if stored for several months, but can be returned to a good workable material when required for use, by 'knocking-up'.

The practice of combining hydraulic limes with pure non-hydraulic lime putty, in order to obtain the benefits of earlier setting in certain conditions, or to achieve more durable mortars, is supported by analysis of historic mortars. This has shown that modern commercial limes, both non-hydraulic and hydraulic, are purer than those generally used in the past and that modern lime mortars tend to be more homogenous than traditional mortars. *(See 2.4.5).*

2.2.3 Sands and aggregates.

Aggregates will generally form the greater part of a mortar, and the characteristics of the chosen aggregate are critical to the performance of the mortar. The specification of aggregates for use in mortars has, in recent times, tended to rely on the relevant British Standards. (BS 882, 1199 & 1200.) These are currently being replaced by European Standards, many of which are at the draft stage. Some aggregates specifically excluded from these standards, for example limestone sands, may be beneficial in producing traditional lime mortars.

Aggregates act as a filler providing the 'bulk' of the mortar, and they contribute to its strength. Aggregates with air-entraining properties may aid carbonation and frost resistance. Those that contain pozzolanic material may improve setting or durability. The colour of the finest aggregate particles will also tend to determine the colour of the mortar.

Traditionally, the aggregates used in lime mortar for external coatings, as for other uses, were natural sands and gravels taken from riverbeds or pits, sand dunes and beaches. In Scotland these were generally siliceous, and therefore made no significant contribution to the setting of the mortar, but some sources produced carbonate sands or had additional mineral contents, which can produce more complex reactions in a mortar. These natural sands usually contained a wide range of particle sizes, including some larger pebbles. Traditional mortars have been found to include other materials such as crushed old mortar, crushed brick and occasionally, stray materials such as fragments of wood. Beach sand, which may or may not have been washed to remove any salt, often contained crushed shell, improving the set, increasing entrained air and giving a distinctive texture to traditional harling.

2.2.4 *Selection of aggregates.*

Sands chosen for external lime coatings should be good sharp 'concrete' rather than 'building' sands, whose angular particles fit closely together, bonding the material and reducing shrinkage cracking (as opposed to the rounded grains of soft sands). Generally, the texture of a harl will be determined by the larger aggregate particles, while colour, if of importance in the selection, is influenced by the smallest particles.

Except where a specific match is required to surviving historic material, sands should have a well-graded range of particle sizes from around 5mm down to 0.1mm. Large, uniform pebbles should be avoided, particularly those of a dense, impervious nature. They produce an over-rough texture, not traditional in harling, and their use may cause limewash finishes to weather rapidly, leaving a speckled appearance. It may be sometimes necessary to include a proportion of larger pebbles with the general aggregate if required to match the character of original work.

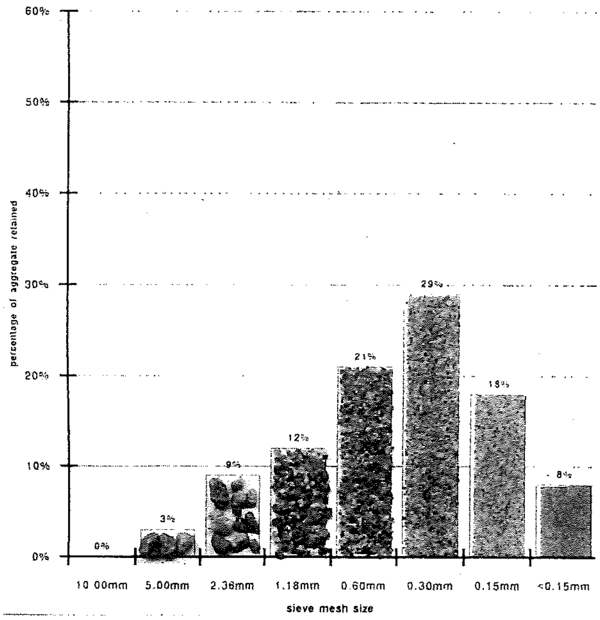


Fig. 17 Composition of suitable aggregate, showing range of particle sizes and shapes. A sand with a similar range of particle sizes but without the largest particles, would also be suitable for use in a finer textured finish.

Modern cement based harls often use building sand, of unspecified origin, for the underlying scratch coats, and a uniform sized stone chip for the harling coat. This approach is not appropriate for traditional lime harls.

There are a large number of operating sand and gravel quarries which produce suitable sands for use in lime mortars for external coatings. Details of these, together with analysis of the aggregates that they produce can be found in Technical Advice Note 19 *'Scottish Aggregates for Building Conservation'*.

2.2.5 *Carbonate aggregates.*

The use of carbonate aggregates, containing calcium carbonate as a proportion of the overall aggregate, can improve carbonation and internal bonding of the mortar. Shell materials in beach sands, crushed limestone and re-used original harl or mortar may all have this effect.

2.2.6 *Pozzolanic aggregates.*

In simple terms, pozzolans are materials with a reactive silica and alumina content which, when incorporated in a lime mortar, will mimic, to a certain extent, the hydraulic setting action. Their effect is generally to increase the initial speed of set and/or the overall strength of the mortar. Pozzolanic additives found in historic mortars include brick dust, coal ash and wood ash.

The most readily available suitable modern pozzolan is fine brick dust (below 50 microns). Purpose-made expanded clay materials can also be used as pozzolanic additives in lime mortars. High temperature insulation powder (HTI), although sometimes specified in recent years, may be less suitable, or effective, than either of these. Other materials, such as pulverised fuel ash, (PFA), should be viewed with caution as their use can produce very hard brittle mortars.

Coarser brick particles, porous aggregates and shell will also introduce air into the mortar structure. In lime mortars this is a valuable method of encouraging carbonation.

2.2.7 *Crushed clay tile aggregate.*

Due to their pozzolanic setting properties mortars containing an appropriate crushed tile aggregate may be considered for use where an increased thickness of mortar is required, for example in making good wall surfaces prior to harling.

2.2.8 Cement.

The gauging of lime mortars with cement is not recommended.

It has been recent modern practice to add Portland cement to lime coating materials in order to produce an early set. Evidence shows, however, that gauging with small proportions of cement inhibits rather than improves performance. Cement also increases the density and reduces the permeability of the coating, and so compromises the way the lime mortar functions. Small amounts of cement are difficult to distribute within the mortar, creating relatively hard and soft patches.

The transfer of soluble salts from cement mortars into porous stones may result in stone decay from subsequent crystallisation.

(Current evidence also suggests that, in certain specific circumstances, some stone damage can also occur in connection with lime mortars. The surface decay of granite in the presence of gypsum is now recognised as occurring with lime, as well as with cement, mortars.)

2.2.9 Hair and fibres for reinforcement.

Animal hair provides tensile reinforcement and reduces shrinkage in mortars by cross matting. It may be added to mortars used for pinning out walls, to a first floated coat and also in some instances to the first coat of a harl. It should be clean and sterilised, and be between 25mm and 100mm long. Goat hair, cow hair or horse body hair are all acceptable. The process of incorporating hair into the mix is described at 2.4.3.

2.2.10 Water content.

Water for mortars should be clean, and free from impurities that would adversely affect the mortar. Water should not be salty or brackish. The specific quantity of water required in the mortar or harl mix will be subject to conditions during mixing, and therefore will have to be assessed on site. Where a previously made mortar is thinned-down for harling, the use of limewash or lime-water is recommended to avoid weakening the mix. Lime-water may be produced by steeping non-hydraulic lime putty in a barrel of water, and then drawing off the lime-saturated water from the top.

2.3 Other construction and repair materials.

2.3.1 Replacement stone.

The geological origin of the stone, its size and the method of building should all be selected to match original adjacent work. It is important to understand the nature of the wall, in elevation, section and plan, before attempting any repair or replacement work. Ashlar stone may be replaced to exactly match existing stone sizes or part stones may be indented. In rubble work replacement is more complex, requiring a clear understanding of the materials and method of construction.

All replacement stone should be clean, dry and free from vegetation and any salt contamination. Wherever possible it should be locally sourced, or salvaged from downtakings, to ensure a close match with the remaining original work. In selecting second hand stone it is important to avoid using stones which may be contaminated, for example by road salts or flue gases, or which may be affected by surface decay.

2.3.2 Pinnings.

Pinnings, also termed snecks or, in some areas, cherry-cocks, were traditionally used to pack the wider joints and other interstices between the large and often irregular stones of rubble work. Pinnings are always placed into the joints between stones, and are normally built following the principles of bedding found in the wall construction, leaving their edges exposed on the outer face of the wall. (See 3.3.1). Pinnings can also be found in some ashlar work where they served to support and stabilise individual blocks during construction.

Fig. 18 Preparing a range of suitable materials from which to make pinnings.

Pinning stones are essential in the preparation of uneven or eroded masonry backgrounds, which usually require to be built out to a more or less level surface prior to application of a lime based coating.

Traditionally, pinnings could be any type of stone (in the case of worked stone, pinnings were normally chippings from the building stone), small pieces of slate and, where locally available, shells (often oyster shells), or pieces of soft burnt brick or tile. Selection of an appropriate pinning material for use in repair work will depend on the nature and character of the host material. It may sometimes be appropriate to utilise a more permeable pinning material to aid carbonation of the mortar when filling voids within impervious masonry.

2.3.3 *Gallets.*

Where wall surfaces are uneven, or where decay has eroded the surface of individual stones, it may be necessary to 'fair-out' the wall prior to harling. The materials used are generally the same as those used for pinnings. The distinction between 'fairing-out' and pinning is in the method of placement of the materials. Small gallets may sometimes be found placed at the surface of the wall, pressed into a mortar backing, commonly leaving a surface exposed to receive a render or harl coating. (See 3.3.1).

2.4 Obtaining or producing lime mortars.

The basic ingredients for external coating mortars are sand and lime, as for other types of lime mortar, and the lime mixes should be made and matured in the same way as other lime mortars. Depending on the materials specified, lime and aggregate may be combined to form the mortar in a number of ways, as described below. More detailed information is contained within Technical Advice Note 1 *'Preparation and Use of Lime Mortars'*. Ready made and matured mortars, including hot-mixed mortars, can be obtained from specialist suppliers and these can be knocked-up, and gauged with pozzolans or hydraulic lime if required, for use on site. For use in surface coatings these mortars will normally be thinned down.

Thorough beating or compressing and good maturing of the basic mortar mix are essential for achieving good performance. The best mixes for external coatings are likely to result from the thinning down of good quality matured, and subsequently knocked-up, lime mortar. Currently large quantities of mortar are normally made in a roll pan mixer, or a paddle mixer, and small quantities may be made by hand but, whatever the method of producing mortars, thorough mixing and beating is essential. Stirring together lime putty, sand and water will not produce an effective mortar.

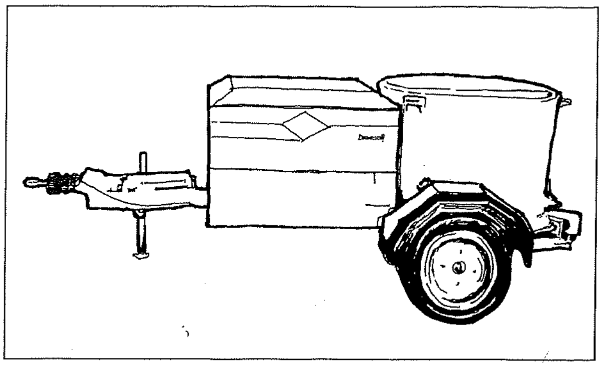


Fig. 19 A roller pan mixer.

2.4.1 *Slaking quicklime and aggregate.*

In principle, the simplest method of making mortars is to combine quicklime and sand and slake them together. The mortar might sometimes be used immediately (i.e. a hot lime mortar), but for harling or other surface coatings the mix should normally be left to mature for several weeks in order to fatten up and guard against the possibility of incomplete slaking. If slaking continues after application, 'popping' of the surface may occur, which would be more obviously damaging to smooth lime coatings.

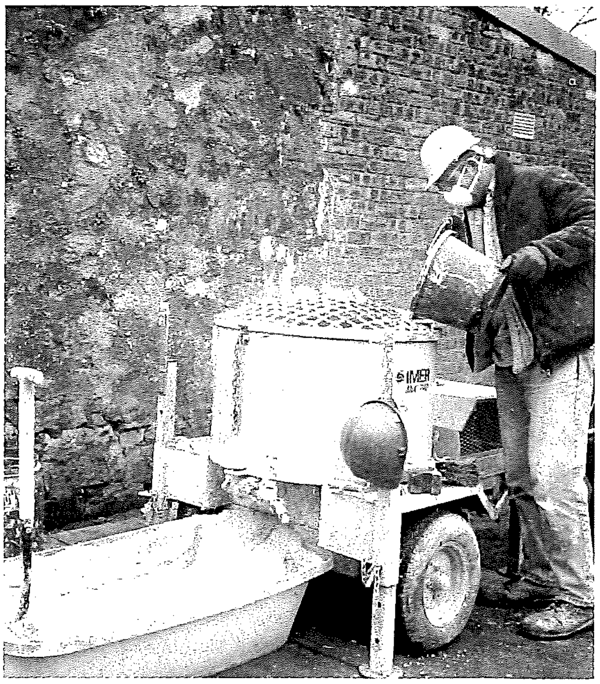


Fig. 20 Quicklime being slaked with aggregates in a paddle mixer. The 'hot lime' mortar was for immediate use.

2.4.2 Mixing lime putty and aggregate.

Non-hydraulic lime mortar for harling, as for other purposes, is frequently made by combining lime putty and aggregates. This may be done on site or by a specialist supplier of ready-made traditional mortars. In either case there should be the opportunity to allow the physical properties of the basic materials to be adjusted to suit the site conditions and for specific uses.

To make the basic mortar, materials are combined by beating and ramming by hand or in a mechanical mixer. After appropriate maturing and knocking-up, the mix will need to be thinned down to a suitable fluid consistency for application of the harling or render.

Traditionally, mortars were probably made up by hand, in an open-ended wooden trough or plasterer's bath, using hoes, larrys or heavy-duty tampers.

In making new mortars hand mixing will usually be sufficient for very small-scale projects. The procedure is to first beat the lime putty and aggregate to combine them together, to allow this mix to stand, covered against rain, frost or evaporation for several weeks (a period of 12 weeks is recommended), and later to re-work the mortar on a clean surface to return it to a plastic state.

Mechanical mixers are required for making larger quantities of material. The best type of mixer is a roller-pan mortar mill as it provides compression of the mortar, thus achieving a good intimacy between lime and aggregate. Rollers should always be set to avoid crushing the larger aggregate particles in the mix. A paddle mixer is a reasonable alternative. For constructional preparation work or 'making good', the basic mortar should be matured and knocked up before use. For surface coatings, the basic mortar should also be matured and thoroughly knocked up, *before* thinning down for use with lime-water or lime wash.

Although it is relatively common to see fluid lime mixes for harling made up on site, from putty and sand, in rotary drum (cement) mixers, this method is not recommended for two reasons: a) these machines cannot provide compression, and b) there is no opportunity for maturing the mix prior to use. Rotary drum mixers might, however, be effectively used for knocking up previously made and matured lime mortar which is being thinned to a fluid consistency for harling.

Where mixes made up from (hydraulic) dry hydrates are to be used for surface coating, use of a rotary drum mixer is possible, although the mixer will need to be allowed to run for longer than is normal practice in making cement mortars. Mixing for up to 15 or 20 minutes is beneficial.

More detailed descriptions of mixing mortars are available in TAN 1 *'The Preparation and Use of Lime Mortars'*.

Knocking-up is the process of returning mortar to a pliable state immediately before use. For larger quantities, or for a stiff well-matured mortar, the knocking-up process may be carried out in a roll pan mixer. For smaller quantities, beating and chopping by hand will be possible. This will reactivate water in the putty, and should produce a plastic workable mortar suitable for repairing walls prior to application of harling or other lime mortar coatings. This stage may be recognised when the mortar retains its shape when moulded in the hand, is sticky but not wet, and clings to the trowel. Lime mortar mixes for casting on (harling) or float application ('render') are generally wetter than that used for pointing, to provide a consistency suitable for casting or spreading. The extra water or, preferably, lime-water or limewash, required should not be added until after knocking up the mortar.

2.4.3 Adding hair to a mortar.

Animal hair has traditionally been used to improve tensile strength and reduce shrinkage in internal lime plasters and, sometimes, in external coatings as well. The hair should be clean, sterilised and grease free, untangled and around 25mm to 100mm long. Imported goat or yak hair is available and is widely used. Other types of hair such as cow or horse body hair (mane and tail hair is generally too springy) are also suitable. In some areas hemp or jute fibres served a similar purpose and, in modern practice, polypropylene fibres have sometimes been used, although there is currently no evidence on their performance.

The generally accepted proportion of hair in mortar is about two handfuls per 20-litre bucket. Small amounts at a time should be teased out into the mix. The traditional method of determining the correct quantity of hair is to check the 'beard' of hairs around the edge of a trowel when mortar is lifted from the mix. Hairs should be visible as a well distributed 'beard' at around 1mm spacing (i.e. very closely spaced). Hair should only be incorporated into mortar shortly before use, as it will rot on prolonged contact with uncarbonated lime.

2.4.4 Mixing hydraulic lime powder and aggregates.

Hydraulic lime materials will set in water and therefore cannot normally be supplied in wet forms such as putty or pre-made mortars. They are supplied as dry powders (hydrates), which should be blended with the aggregate before adding clean water.

Hydraulic lime mortars will often be made up immediately in advance of use, enough for two to four hours work, but longer standing times may be possible. Thorough mixing for 15 to 20 minutes is beneficial. Mortar must be used before the set becomes established, or otherwise discarded. The setting time of hydraulic lime mortars will vary according to strength and local conditions, and it is sensible to carry out test samples on site to establish setting times. Feebly hydraulic limes can often be made up the day before use, left to stand overnight and, the following day, knocked up in batches as required.

2.4.5 *Blended mixes of putty, hydraulic lime powder and aggregate.*

Non-hydraulic lime and hydraulic lime can be blended to achieve various degrees of hydraulic set. This allows variations to be made to suit local conditions, and to more closely match original mortars. The hydraulic lime component (normally 50% of the total lime content) should be mixed to a slurry with clean water and added to a pre-mixed lime putty / aggregate coarse stuff. These are known as gauged mixes or composite mixes and, like hydraulic mortars, must be used before a set occurs. The hydraulic lime slurry is normally added to a lime putty based coarse stuff during the knocking up process.

2.4.6 *Blended mixes of hydrates.*

The hydrated powder form of non-hydraulic lime is not recommended as a substitute for wet-slaked non-hydraulic lime putty. In certain situations, (for example where the transport of wet materials to a remote site is not possible), it may be considered for use in combination with an eminently hydraulic lime.

It is usually desirable to run the non-hydraulic hydrate to a putty and allow it to fatten up for a few hours before combining with the hydraulic material and sand.

2.4.7 *Batching and gauging.*

Wet materials such as putty, made-up mortars and damp sand, are usually mixed by volume. Volumes of materials are most conveniently measured in buckets or similar containers, and care must be taken that each bucket contains the same amount of material as the last. Dry hydrate materials will have varying volumes depending on bulking and should therefore normally be measured by weight, to achieve accurate batching.

Accuracy and consistency are important when weighing and blending materials, in order to achieve an even and consistent mix; otherwise variation in the properties of the finished coating, such as hard and soft areas, may result. See TAN 1 *'Preparation and Use of Lime Mortars'* for more detailed information.

2.4.8 *Handling and storage.*

Lime putty and non-hydraulic or feebly hydraulic mortars will improve with storage and maturing, provided they are kept in a moist condition, and are well covered to avoid rain, frost or evaporation.

Lime putty should be matured in breather bags or pits that allow excess water to drain off, and should be protected from frost.

Hydraulic lime powders must be kept in dry conditions (as for cement). Bagged hydrates should be used relatively fresh and in rotation, in accordance with the suppliers' stated limitations.

In accordance with normal good site practice, aggregates should be stored separately on hardstanding and covered to prevent excessive wetting.

Ready made mortars will be delivered to site in 40kg (or other) bags, or in bulk using 1-tonne industrial bulk container bags. The material may be stored outside provided it is protected from frost, and is not allowed to dry before use.

Where mortars have been mixed on site they should be stored in covered heaps and not allowed to dry out.

Skill and judgement will be required to determine the extent to which a mortar mix should be thinned down for use. This will depend upon a number of factors, including environmental conditions and the specific location for, and purpose of, the proposed lime coating. Knocking up, as described in 2.4.2, will always be necessary before use, after delivery or site storage of a pre-mixed mortar. The site preparation and use of traditional lime mortars for external coatings is described in detail in chapter 3.

Fig. 21 Damage following removal of modern paint coating.

Fig. 22 Remnants of original lime harl.

3. SITE PRACTICE IN APPLICATION OF EXTERNAL LIME COATINGS

3.1 General principles.

In addition to the knowledge required to achieve good mortar mixes, as described in chapter 2, skilled craftsmanship and good site practice are of fundamental importance to the success of external lime finishes. While the site practices required for lime based finishes are generally no more exacting than the approved practices set out for cement based work, lime based finishes are much less tolerant of the short-cuts commonly applied to cement harling and rendering and, in their early stages, are more susceptible to damage from inclement weather. Well-executed external lime coatings need to be preceded by thorough preparation of the background, and to be followed by aftercare and protection to allow them to become established under suitable conditions.

The season for all external lime work in Scotland is generally from April to September, although, with adequate protection, it may be possible to extend this period. Winter working is not generally recommended without comprehensive protection and strict control and monitoring procedures.

3.2 Existing finishes.

Surviving historic lime finishes are relatively rare and, as a general principle, any existing external lime coatings should be retained if possible. In particular cases specialist conservation techniques, such as edge pinning and grouting (see 3.8.3), may be appropriate. However, with lime – which is unlike cement in this respect – it is almost always possible to patch in and 'feather edge' new work to the old. The specification of new mortar should be closely matched to the old, which should, if necessary, be analysed (See 7.2.2). Modern cement rough cast or render and impervious paints should be removed prior to the application, or reapplication, of lime coatings. Cement pointing should normally be removed if this can be achieved without major damage to the masonry.

3.2.1 Removal of cementitious coatings and pointing.

Although they often become detached, hard cement renders or pointing may adhere strongly to underlying stonework and may be keyed deeply into the joints and stone faces. Considerable care should be taken during removal so as to minimise damage to the masonry.

It is usually preferable to remove cement roughcast and render by hand with small tools, and removal from carved stone details must always be undertaken with extreme care by hand. In certain situations, power tools, such as small power or air chisels, can be effective for removal from larger flat areas, as their percussive action can loosen large sheets without the loss of stone or even, potentially, destabilisation of masonry, that may result from hacking by hand. Removal must always be undertaken with care and intelligence.

Cement pointing should be picked out with care. Narrow joints can often be cleaned out using hand held hacksaw blades. For other joints suitably narrow chisels that will not damage adjacent stones may be used. Where wide joints exist, a series of small holes, carefully drilled along the exact centre line of a joint, may allow the cement mortar to break inwards when tapped. This technique should not be used where there is risk of damaging masonry behind the cement, for example in finely jointed ashlar walls.

3.2.2 Painted or treated surfaces.

Masonry and surviving lime coatings may have been treated with plastic paints, cement paints or sealants, most of which are significantly less permeable than lime materials. In particular, film-forming paints tend to trap moisture behind them, leading to accelerated decay of the substrate or flaking of the paint layer itself.

Masonry may have had previous treatments that are damaging to the fabric and incompatible with new lime based coatings. It is not normally possible to apply lime coatings over substrates treated with water repellent or consolidant materials, as insufficient suction is given to the harl, resulting in lack of adhesion, and the object of achieving permeability in the wall is defeated. If the previous use of a silicone, or similar, surface treatment is suspected, the condition and degree of suction of the masonry should be evaluated before deciding to apply a lime based coating.

Previous treatments may be difficult to remove, and some may be irreversible. Caution is required with all the available removal techniques, including proprietary paint removers and mechanical abrasion. Acid- and alkali-based cleaners may seriously damage stonework or existing lime materials, and residues may remain in the substrate to compromise later repair work. Mechanical abrasion is almost always damaging. Steam cleaning may sometimes be used for removing plastic and cement paints, by loosening the 'membrane' which may then be scraped off. New methods of 'cleaning' stone surfaces are promoted from time to time and specialist advice should always be sought before attempting any form of cleaning. Further information on cleaning stonework is available in Historic Scotland's, *'Stonecleaning – A Guide for Practitioners'* and in TAN 9 *'Stonecleaning of Granite Buildings'*.

Fig. 23 Where masonry is eroded or pinning stones have been lost, surfaces require repair before application of harling or render.

3.3 Preparation of wall surfaces.

External lime coatings should normally be applied in relatively thin layers and should be regarded only as the final protective coating. Where deep hollows in the wall face require filling out, this should be done by packing out the mortar with small pieces of stone or other material as described below. The coating itself should not be 'dubbed-out' in large masses in the way that a modern cement 'dubbing-out coat' is conventionally applied, since this would result in uneven thicknesses of the material, which would compromise carbonation and curing and would be subject to shrinkage cracking. Detailed consideration of the nature of the masonry and the building character and context will be required for each individual case, to determine the extent of preparation that is appropriate prior to applying the thrown or float applied finishing coats.

3.3.1 General preparation.

Sound backgrounds.

Where existing masonry backgrounds are sound, with relatively flush joints that are fully filled with pinnings and mortar, then only minor advance preparation, to remove any loose surface material, soiling or vegetation, is necessary. This should be followed by whatever measures are required to control suction or, where necessary, to establish a physical key (see below).

Weathered or eroded backgrounds.

Where natural weathering and unsuitable previous repairs have left masonry with an excessively uneven face, considerable repair work may be required to bring the wall surface to the profile required for the finished work. This is achieved in the main by replacing lost pinnings and packings, which are the small stones traditionally built into any wide joints between larger stones in rubble built masonry. (See 2.3.2). Missing larger stones, and soft or badly decayed stones, may have to be fully replaced. Stones with partially eroded faces may be also need to be brought forward by embedding very small pieces of stone, tile or other suitable material, known collectively as gallets, in lime mortar onto the surface of the wall. (See 2.3.3). Guidance on carrying out repairs to eroded masonry, prior to application of external lime coatings, is given in chapter 4.

3.3.2 Vegetation removal.

Where masonry surfaces are to be coated with lime-based finishes, all lichens, moss and vegetation should be removed using a compatible biocide and bristle brush, or a steam cleaner. All forms of biological growth will retain moisture and can grow back through the new coating. Any application must be tested to ensure it has no adverse effect on the existing masonry or any surviving clay mortars, as well as being suitable for use with the new lime material. Advice on removal of biological growth is contained in TAN 10 *'Biological Growths on Sandstone Buildings: Control and Treatment'*, 1997.

3.3.3 Suction and bonding.

Before applying lime coatings it is important to check that a good bond can be achieved with the substrate. In most situations measures, such as dampening down, may be required to modify the suction characteristics of the substrate. Excessive or rapid suction, between substrate and mortar or between mortar coats, will draw water from the new mortar, resulting in a weakened interface and the risk of later separation. If there is no suction other measures may be required to create a bond. Where the stone, or other, substrate is decayed or friable a weakening of the bond may be inevitable over the years.

The effectiveness of the bond will be influenced by any of the following: -

- The cleanliness of the surface - loose material, dust, etc. will prevent adhesion.
- The nature of previous treatments.
- The degree of suction - dry porous sandstones will have greater suction than dense whin.
- The nature of the mortar itself - mortars mixed and applied hot will generally create a strong bond (but see 2.4.1).
- The soundness of the surface - a friable or damaged surface may prevent effective adhesion.

Preliminary cleaning down.

Surfaces and joints should be brushed free of loose dirt with a natural bristle brush (not a wire brush) to ensure a good bond, and open joints flushed out with water. Any loose surface materials, unsound areas of existing lime pointing or unsound lime coatings should be removed, as well as any later cement based finishes, before preparation of the surface for the new coating is commenced.

Previous surface treatments.

As noted above, care should be taken to establish whether the masonry has previously been treated with a chemical consolidant or a 'water-proofing agent', as these may repel applied lime mortars due to their hydrophobic properties. Specialist advice should be sought if these treatments are present in masonry which to receive lime based finishes.

Damping down of backgrounds to control suction.

The degree of suction offered by the substrate should be evaluated and, if necessary, modified before application of lime based finishes. Dampening down, to control suction between the background and newly applied materials, is normally essential before placing any lime material, both in pointing or surface coating a masonry background and between each subsequent coat of material. The suction and bonding characteristics of the masonry background should be checked on a small area before deciding the degree of dampening down, if any, which will be required.

Fig. 24 Dampening down before applying coatings.

Porous backgrounds.

Dry porous sandstones will normally have excessive suction, which should be controlled by damping down. High-suction backgrounds may require thorough wetting. The objective is to achieve a thoroughly dampened, but not wet, background before application, in order to control the suction the wall surface exerts on new wet lime mortar. Lime materials initially adhere and stiffen up by suction from the background, and the effect needs to be controlled so as to produce slow and consistent drying. The degree of dampening-down required will depend on the porosity of the background and on weather conditions. Porous masonry may require to be thoroughly dampened the day before work and again just prior to work commencing. Damping down may be done with clean water, followed, if suction is excessive, with a very dilute limewash. Further dampening may be necessary as work proceeds.

Wet sandstone masonry, on the other hand, may offer little suction and might have to be allowed to dry out before application of lime based coatings.

Impervious backgrounds.

Denser, more impervious stones, for example whin or other metamorphic stones, or some granites, have very little natural suction, and lime mortars may not adhere to these stones if there is any surface water present. These impervious low-suction backgrounds may need no dampening. Washing down may be required to remove loose material and dust but the masonry surface should be allowed to dry before application of the new lime coating.

With some dense, relatively smooth surfaced stones it may be necessary to apply a thin 'splatterdash' coat to provide a mechanical key and, in masonry of mixed origin, both the selective application of splatterdash coats (to whin boulders) and dampening (of sandstone) may be required.

The nature of the mortar.

Where the mix is cast onto a sound surface adhesion is generally good. The use of a slightly less wet, and more sticky, mortar is beneficial over impervious backgrounds, and hot lime mortars, mixed and applied hot, are the most tenacious. (See 2.4.1 and the Health and Safety notes at appendix C.)

In the application of flat, float-applied lime renders the consistency and workability characteristics of the mortar are critical, since drying shrinkage and overworking will cause unsoundness. Control of suction is therefore doubly important in the case of float applied coatings, both to avoid weakening the bond and to avoid altering the working properties of the mortar material.

Decay or breakdown of the stone surfaces.

Masonry surfaces themselves may be friable or may be damaged within the surface layers, possibly as a result of the previous application of cementitious renders, or due to natural weathering of, for example, argillaceous sandstones. In order to achieve a good bond it may be necessary first to treat the masonry surface. Loose powdery material should be brushed away to reveal a sound surface, which may then require further treatment.

In England the application of a very dilute limewash, or multiple applications of lime-water, have been used with some success on friable limestone and sandstone backings, but experience of this technique in Scotland is limited as there are few limestone buildings. Spray application of a mix of one litre of NHL3.5 (moderately hydraulic lime) in five litres of water has been used on sandstone surfaces. It is possible that application of a mix that is sufficiently dilute to pass through a sprayer will penetrate a damp masonry surface, but care should be taken to avoid use of a stronger mix, which might form a detachable layer on the face of friable stone. Whatever methods of preparation are used, it is likely that lime-based (or cementitious) coatings over decayed and damaged stone surfaces will be less durable than similar coatings over sound masonry.

In some situations it may be appropriate to dress back the decayed stone to a sound surface before rebuilding in lime mortar with pinnings and packings, in preparation for application of a lime based coating. In other situations the indenting of sound stone might be considered.

3.3.4 Salt contamination.

Application of mortar coatings, whether lime based or cementitious, over salt contaminated masonry can present significant problems. A common cause of salt contamination is from ground water, which may contain sulphates, nitrates and chlorides. Other common sources are flue gases and contamination from road salts. In coastal locations sea winds or sea spray can result in a significant salt content in the masonry. Storage of fertiliser, gunpowder and other substances can also result in the presence of chemical salts in masonry. Where the source of salt contamination can be removed, or the masonry isolated from the source, then a process of sacrificial poulticing, using clay and/or lime mortars, might be considered before application of a new lime based coating. Specialist advice should be sought if this technique is being considered. Alternatively, the new lime coating might in itself be considered as a sacrificial coating, to be renewed as salts are drawn into it from the masonry.

In most instances removal of the source of contamination is not possible, and the only course of action may be to attempt to reduce the problem by preventing the movement of moisture through the contaminated masonry. In the case of rising ground water (rising damp), measures to be considered may include lowering of external ground levels, introduction of ground drainage to lower the water table, removal of hard ground finishes and provision of an evaporation zone adjacent to the base of the wall, etc. Where effective remedial measures are not possible, a new lime coating will act as a poultice, drawing salts into itself, and may require frequent renewal. If salts remain in masonry which is subject to movement and evaporation of moisture then this process of renewal of the lime coating will be an ongoing requirement. Some suppliers produce hydraulic lime materials which are claimed to have the capacity to absorb relatively high levels of salt contamination without breaking down, but experience of their long term performance in Scotland is limited.

Although it may be thought that application of a cementitious coating would reduce the problems associated with salt contamination, this is not the case. Salts will generally crystallise at the interface of stone and coating, causing significant decay to friable stone, which may already damaged by the salts. The result could be rejection of the cement based render, often in large sheets. In addition, by significantly reducing, or preventing, evaporation of moisture from the wall face, the presence of a cementitious coating will force ground water to rise further up the wall, transferring the salts to a new location and increasing the area of contamination.

3.4 Lime harling.

As described earlier, 'harl' is the Scottish term for a lime mortar coating applied by casting or dashing onto a wall. There is some evidence that harling was once the thrown mortar finish commonly applied to external and internal surfaces of rubble walls, prior to plastering if a more formal finish was required.

Lime harls were normally thinly applied and usually of a coarse but even consistency. Observation of old harls suggests that the material was applied directly onto the surface of the masonry, sometimes as a single coat, occasionally in two (or more) coats. In Scotland harling was almost never applied over a floated coat. This contrasts with the modern practice in cement work which involves application of a dashing coat over a trowelled floating coat. There are strong technical

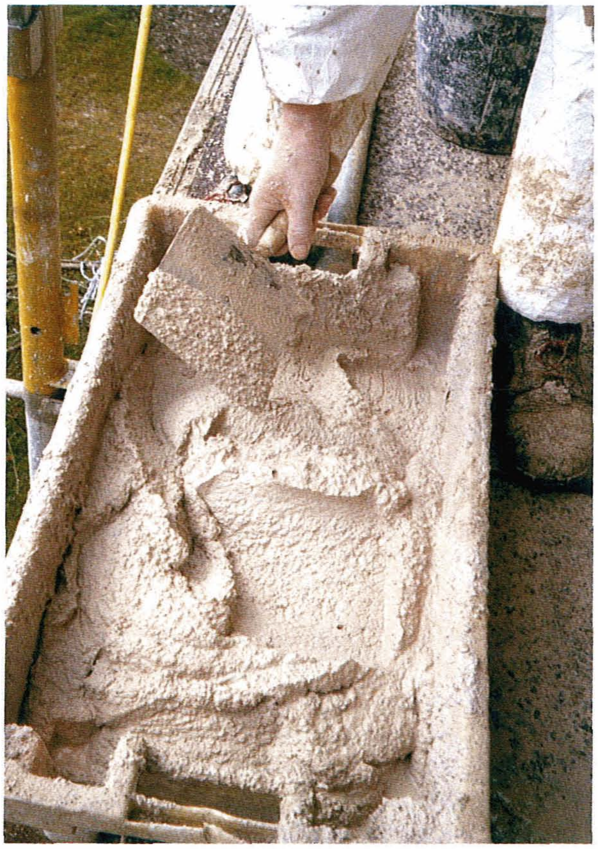


Fig. 25 The consistency of mortar suitable for harling.

reasons for casting-on lime harl. Casting-on allows each coat to be thin and discourages 'dubbing out' of hollows with the trowel: where hollows require to be brought out this is achieved by casting in preliminary coats prior to the main application and, if necessary, by further coats in the hollow areas as the earlier coat sets up. An even finish can be achieved, with good adhesion to the background, which aids carbonation of the lime and keeps shrinkage of the mortar to a minimum. It also allows feathering out of the harl thickness where necessary at junctions with masonry features. When masonry backgrounds have been suitably prepared, harling is a straightforward and relatively quick exercise.

3.4.1 Preparing the mortar for harling.

As described in 2.2.10, the best method of making mortars for harling is to thin down an appropriate, previously prepared and matured lime mortar. Before use the mortar will require to be knocked up, this process is described at 2.4.2. It involves the reworking of a previously made lime mortar and, in the case of a harling mix, thinning it down to a fluid consistency for casting on. The extra water, or, preferably, lime-water or limewash, required to achieve this fluid consistency should not be added until after knocking up the mortar.

The precise fluidity of the mix is a matter for the individual craftsman but thick sticky mixes should be avoided as they will result in uneven lumpy coatings, with a poor appearance and, potentially, poor performance.

3.4.2 Techniques of application.

Backgrounds will normally need to be dampened down prior to harling in order to control the effects of suction. (See 3.3.3). A new application of lime harling onto a sound, even background should generally be in two coats of approximately 8mm and 6mm thickness respectively. A thin single coat application is also possible but this may be less durable in exposed locations. For application over porous sandstones in exposed locations, a thicker coating is likely to be required to minimise absorption of water into the stone itself.

Where a thicker harl is required, the material should be built up in several thin coats. As in modern construction, it is good practice for each subsequent coat to be thinner, weaker and more permeable than the preceding coat. As a general principle the thickness of the coat is also dependent on the size of aggregate; however in practice this is not always the case. Techniques of applying harl to eroded or decayed backgrounds are discussed in chapter 4.

The best tool for applying harling is a purpose-made 'harling trowel'. This has a square, slightly curved blade with no sides, on which the mortar may be scooped up, spread evenly on the blade, then hurled at the wall with a flick of the wrist. This is a technique which requires practice in order to achieve an acceptable standard of finish on the wall.

An historic harl finish sometimes exhibits patterns derived from the methods of casting. These patterns are an intrinsic part of character of the harl, and any repair work should be in keeping with surviving adjacent finishes. An even casting action is needed to ensure a consistent distribution of the material; otherwise differential thicknesses may occur. Casting will be eased if both 'forehand' and 'backhand' can be mastered, allowing a larger area to be reached from one place and awkward details to be negotiated.

Modern methods of mechanical application, although they may be technically sound in some situations, are unlikely to produce an acceptable result in traditional harling work. If spray application *is* used it should always be finished with a hand cast top coat.

The first coat of a harl may need to be lightly pressed back with the back of the harling trowel, or with a stiff bristle brush, as it starts to set, to remove any high spots. Care should be taken not to over-work or smooth the surface, but just to push it back.

Fig. 26 Standing at right angles to the wall, harling is applied with a flick of the wrist. Care should be taken to avoid 'fan' patterns in the finished work unless to match the existing adjacent finish.

Each layer of lime material should be allowed to cure, normally under protective coverings as described in 3.9, and then be re-dampened before applying another layer. The final layer should be cast on in the same manner as before, and may be given a variety of finishes. (See 3.4.4).

3.4.3 Harling up to dressed stone details.

Where harling stops against dressed stone masonry care must be taken not to form raised edges. These edges are vulnerable to water penetration which may lead in the future to detachment of the coating. Details such as raised margins and string courses offer protection, allowing the harl to be tucked behind. Details without a positive edge, such as canted ingos, crow-steps, and external angles, require extra thought and skill in application. The material can be cast progressively thinner as it approaches the detail so as to die away to nothing. This is known as 'feathering-out'. Care may be required to ensure the mortar does not encroach onto adjacent masonry or other surfaces that are to remain exposed. In many situations it will be appropriate for the limewash finish to be taken over both the harled surface and the dressed stone. This will seal the junction between the two, giving additional protection against water penetration.

Fig. 27 Working up to dressed stone. Note safety protection worn by operatives.

3.4.4 Harling finishes.

Traditional Scottish harling was often a relatively sophisticated finish, contrary to the common modern interpretation of Scottish harling as a rough, open-textured finish. The basic finish was obtained by leaving the material as cast, (although it may have been necessary to press back high spots), and from using a coarse, though well graded, aggregate.

Lime harls can be given different finishes by working the surface after casting. The simplest method is to press back the harl while it is still 'green' to create a smoother and flatter surface. This may either be done roughly, or more thoroughly to achieve a fine and smooth finish. (See 3.7.1).

3.5 Floated finishes to cast on coatings.

Because of the difficulty of achieving the necessary conditions for the successful application of lime finishes by trowel, the use of casting on techniques should always be considered, even when a flat surface is required. Floated surface finishes may be achieved by the subsequent careful pressing back of a cast on coating.

The techniques of application are the same as for harling, with the exception that the final coat is pressed back to a flat surface after it starts to stiffen up but whilst still green. Techniques of surface finishing can be applied, as described below at 3.7. Care must be taken to avoid overworking the material.

3.6 Float-applied lime coatings (renders).

3.6.1 Preparing the mortar.

The consistency and properties of lime mortars for float applied coatings are likely to have a significant impact on the quality and durability of the finished work. The mortar should have a good spreading consistency, which will allow firm application without over working, but should not be so wet that the result is excessive drying shrinkage. These properties will be influenced both by the water content of the mix and by the selection of appropriate sands or other fillers. The use of previously made and matured lime mortars, well knocked up before use, will also be beneficial in achieving workability without a high water content.

Techniques of preparing the mortar for application by float are essentially the same as those for casting on and involve the knocking up of a previously made lime mortar and, subsequently, thinning it down to a suitable spreading consistency. The consistency of mortar for floated coatings is critical (see below). The extra water, or, preferably, lime-water or limewash, required to achieve the appropriate consistency should not be added until after knocking up the mortar. If hair reinforcement is required, as described at 2.4.3, it should be added during this knocking up stage.

3.6.2 Techniques of application.

Site practice in the application of flat, float applied coatings is particularly critical. Site practice, in turn, is influenced by the consistency of the mortar itself. Techniques of application must be employed which minimise drying shrinkage and cracking during curing, as excessive scouring to tighten in shrinkage cracks will draw lime and other fines to the surface. This surface laitence can compromise the bond between coats and inhibit carbonation of the material. The migration of lime to the surface will also result in a weak mortar layer, susceptible to frost damage.

As for casting on, the masonry background should always be brought out to a more or less level profile as a separate exercise before application of the first coat. The coating should be applied relatively thinly, with any necessary filling out of deeper hollows completed prior to application of the coat, by dubbing out and packing the mortar with small pieces of stone or other suitable material. It is particularly important to observe this technique as significant variations in thickness of the coating material itself will result in shrinkage cracking on drying. Surfaces to be coated also need to be fully prepared, including dampening down, or other measures as appropriate, to control suction and increase the bond, as described at 3.3.3.

Float applied lime finishes will often consist of two coats, although more may be needed in some circumstances depending on the background conditions and the surface finish required. It is generally beneficial to include hair reinforcement in the first coat and, sometimes, in the second coat. The first coat is applied with a float to a thickness of approximately 8 to 10mm. (3/8" or the thickness of a little finger.) As the material starts to stiffen up, it should be compressed and scoured in place with a wood or polyurethane float, with a circular motion of the hand, avoiding excessive working of the surface, to close up any cracks caused by shrinkage as the material dries. The surface is then lightly keyed by scratching, (not cutting through), in a diagonal pattern.

Before applying a second coat, the first coat should be allowed to carbonate gradually over a number of days, using full protection and regular dampening down, as site and climatic conditions dictate. Good curing conditions to minimise drying shrinkage are essential. Any shrinkage cracks that continue to appear should be worked back before the set is established, by wetting and then re-working and scouring with the float. Excessive scouring will weaken the coating. If curing and other conditions are not appropriate, and excessive shrinkage occurs, the mortar should be removed and the work redone.

Fig. 28 Achieving a smooth flat finish.

Before applying the second coat, the surface should be thoroughly dampened down, allowing water to be absorbed, and if necessary it may require re-dampening a second time immediately before application. The second coat is again applied with a float to a thickness of approximately 8 to 10mm (3/8" or the thickness of a little finger) but never thicker than the preceding coat, and compressed and 'scoured' into place with a wooden float as the materials starts to stiffen up, again avoiding overworking of the surface. Good curing conditions are essential to minimise drying shrinkage and, thus, the need for scouring and overworking the surface.

3.7 Surface finishes.

Lime mortar surface coatings, whether cast on or float applied, can be given a variety of surface finishes as described below.

3.7.1 Open surfaces.

With a harling, or cast on coating, an open-textured, but relatively flat, surface may be achieved by pressing back the mortar after casting on. While a flat surface will be achieved, shadows that are cast by the aggregate should still give the finish an open-textured appearance. Wooden or polyurethane floats are useful tools for this purpose. (See 3.4.4).

With a float applied coating, a degree of openness can be achieved by the use of a mortar containing a coarse sharp sand finished with a wood float.

3.7.2 Floated finishes.

Both cast on and float applied lime coatings may also be given a compact plaster or stucco finish by traditional plastering techniques, using a wood or polyurethane float (see 3.6 above). This finish may be chosen where copying an original material, but should be considered with caution due to potential problems associated with surface laitence.

In achieving a floated finish, care should be taken not to overwork the surface and to avoid the use of steel floats, as both tend to encourage the formation of laitence, drawing lime from the body of the mortar, resulting in a weakened material, and inhibiting curing of the underlying mortar. As a result the mortar will be susceptible to frost damage.

3.7.3 Lining-out.

A pressed back harl or floated finish was often 'struck jointed' or 'lined-out' in an imitation of jointing in ashlar masonry. This may have been done in a formal or informal manner, depending on the character of the building. Existing finishes and historical evidence should be carefully studied to ensure new work achieves the right effect.

Lining-out should be undertaken after the surface has been finished and has just reached the 'leathery' stage in the setting process.

To be successful, lining-out must be undertaken with care, ensuring lines are truly horizontal. A spirit level, or plumb bob and square, are normally required. The lines may be struck by running along a straight-edge with jointing keys. The line struck should not be too deep (which could hold water), nor razor sharp. Taking a float lightly again over the struck line should soften

Fig. 29 Lined-out flat lime coating.

the edge. The horizontal lines are struck first, returning where required to do the 'perpends' or vertical lines.

Where there is evidence of original lining-out it should be studied, and recorded where possible, before it is replicated. In new work the size and pattern of 'stones' needs to be convincingly copied. Ensure that lines meet up with stone details such as quoins and margins and follow the rules of real masonry building. With all finishes beware of being too mechanical, old buildings rarely have true planes or right angles and a subtlety in approach usually brings the most successful results.

3.7.4 Sneck harling.

The finish commonly described as 'sneck harling', implying the harling over of 'snecks', or pinnings, but not of the major stones, is often the result of the loss of lime finish from the major stones of what was once a full finish (see 1.3.4). Where there has been significant loss of pinnings repair techniques, as discussed in chapter 4, will be required before casting a further coating of mortar into the hollows between stones. The techniques of application of a sneck harl are similar to those for full harling.

3.7.5 Other special finishes.

Techniques of applying lime harls by casting a wet dash or dry-dash over a 'laying-on' coat are generally not considered as traditional application methods in Scotland and cannot be recommended. Where these methods have been tried, separation of coats often appears to occur. Only where coatings can be shown, through careful study, to have been carried out in this way should these methods be used in a repair.

Other one-off finishes may occasionally be found, such as 'depeter', which involves the pressing of small pebbles into the surface of a wet mortar coating.

3.8 Conservation and repair of existing finishes.

3.8.1 Patching in.

If external lime coatings remain reasonably intact it is almost always possible to patch unsound areas with new materials, using limewash to merge the junctions. Specialist techniques such as grouting and pinning back can also be employed to ensure original materials survive.

When cutting out friable materials, surfaces should be taken back to sound material, while not removing original coatings unnecessarily. The most satisfactory way of patching harling is to 'feather-out' the edges of surviving material and cast on the new harling to overlap these edges, giving a continuity of surface between old and new material. With flat floated coatings, it may be possible to undercut the edge adjacent to the new patch, except at the lower horizontal edge, to provide a key for the new material. The edges of surrounding material should be well dampened to control suction and the background should be dampened down as necessary. A preliminary coating of very thin limewash on the background, and at the edges of surrounding existing material, may be useful to control suction and improve adhesion, if the underlying masonry is dry and porous.

It may be difficult to preserve coatings that have previously been subjected to damaging treatments, such as the application of sealants and plastic paint systems. Removal of paints can be difficult without damaging the lime coating. It might sometimes be better to delay any repairs until the undesirable material has weathered away, simply *gently* brushing away loose material from time to time. The appearance of the wall can sometimes be improved while this process continues by the application of a sacrificial limewash (although it may quickly wash off any remaining painted surface). This will also have the benefit of protecting newly exposed surfaces of the surviving coatings until full repair and limewashing is possible.

3.8.2 Consolidation using limewash and lime-water.

If lime coatings are adhering to the background but are friable on the surface, stabilisation can often be achieved by the application of several coats of thin limewash. The first 2 or 3 coats should be thinned, preferably with lime-water, to around half the consistency of normal limewash and flooded onto the surface. As the surface tightens up, further coats of standard limewash can be applied. This will fill narrow cracks, consolidate friable surface areas and visually merge patched or preferentially weathered areas.

Important, but very friable, lime coatings can sometimes be stabilised by multiple applications of lime-water, which should be repeatedly flooded onto the surface until no more is absorbed. It is important that the coating is wetted through its full thickness, but over-saturation should be avoided. This treatment should be repeated daily for a minimum of 5 days. Increasing the number of treatments over further days will improve the likely success of the stabilisation.

3.8.3 Grouting.

Lime coatings that have become partially detached from the host masonry can often be conserved by repair methods, rather than being removed and replaced. Localised areas of loose material do not necessarily

Fig. 30 Specialist technique of grouting voids behind loose coatings.

imply that the coating as a whole has failed. Boss, but otherwise undamaged, areas will normally survive and continue to perform satisfactorily provided they are not subject to impact damage.

In the most valuable original work, where it is considered important to re-secure detached material, then grouting techniques may be employed, which allow new material to be inserted into the gap between the old render and the wall.

Very fragile coatings should first be carefully supported, perhaps using a braced sheet material such as plywood with a foam layer bearing against the surviving lime coating. Once hollow areas have been identified these should be flushed behind to remove loose friable material, using a dilute (1%) solution of sodium glaucomate. It may be necessary to very carefully drill 'weep holes' through the harling at the base of the boss area to allow the flushing agent and grout to fully penetrate behind the coating. Flow patterns of the flushing agent, once identified, can be stopped at the edges by forming edge fillets in suitable lime mortar.

Grouting behind soft lime coatings is usually done using non-hydraulic or feebly hydraulic lime putty mixed with dilute sodium glaucomate. Small holes are drilled as necessary to allow grout to be injected by syringes, and to permit displaced air to escape. A suitable grout mix may be achieved by using a mature lime putty sieved through a 300 micron gauze, and mixed with lime-water gauged with 3% of a 10% sodium glaucomate solution.

3.9 Protection and curing.

After placing, all new lime based materials need appropriate controlled curing to enable them to achieve their long-term strength and durability. The aim is to provide a moist and *slow-drying* environment in which carbonation may take place. Carbonation may not be completed if the material dries too quickly or is prevented from drying by persistent dampness.

The lack of effective protection of newly placed lime materials is probably the cause of a high proportion of failures, and it will almost always be necessary to provide some form of protective covering to control the immediate environment during curing.

3.9.1 Environmental conditions.

Damage to freshly applied lime coatings may occur as a result of rapid drying by direct sun or strong wind before carbonation has taken place. This will leave the material crumbly and with poor bond to the background or between coats.

Persistent dampness, from rain or defective rainwater goods, will prevent non-hydraulic lime materials from carbonating. Direct rain on uncarbonated materials may cause staining of adjacent surfaces or materials as free lime is dissolved and displaced. Even once full carbonation has been achieved a persistently wet lime finish is vulnerable to accelerated decay.

Below an air temperature of about 5°C, carbonation is likely to be slow, particularly where thicker, wetter coatings have been applied. Frost will damage uncarbonated materials through repeated freeze-thaw actions, leaving the material friable and detached from the background masonry.

3.9.2 Protective coverings.

The best means of controlling curing is to create a 'micro-climate' for the newly applied material. This is reasonably straightforward where the building is fully scaffolded. Adequate shade and protection can usually be provided by full cladding to the outside of the scaffolding with reinforced sheeting or with debris netting. In rapid drying conditions, extra protection is afforded by hanging an inner cladding of sheeting or hessian fixed close to the wall surface. Inner cladding

Fig. 31 Protection placed in front of new harling during cold weather.

needs to be hung in short lengths, so as to be lifted easily for working, and should be securely fixed to avoid it flapping against the newly applied coating. The top of the wall should also be protected to prevent rainwater from running down the face. On small jobs, where no scaffold is used, it will still be necessary to hang protection from eaves or from wall copes.

Drying winds, as well as very hot dry weather, can cause over-rapid drying. Generally, some form of protection is likely to be required at any time of year and winter working is not recommended without adequate attention to controlling the environment. All new lime based coatings should be protected from rapid drying and from rain until a sufficient degree of carbonation is achieved. As a rough guide, each coat of lime material may require a week to ten days of initial curing to reach this stage. Thereafter the new lime coatings should not be exposed to frost until fully carbonated - a process which will take around 12 weeks in favourable conditions, and may take considerably longer in a cold and wet environment. If the coating has been carried out late in the year carbonation may not become fully established for several months (activity is minimised below about 5°C) and protection may be required until the following spring. If there is any risk of freshly applied lime coatings being exposed to frost, additional protection will be necessary. This might include the need for some thermal insulation to prevent the temperature of the 'green' mortar coating falling below freezing point, since the formation of ice crystals will disrupt the integrity of the material. Bubble wrap and straw blankets have been used successfully to insulate lime coatings during the drying process.

Ducted warm air from propane gas heaters can provide a good, carbon dioxide rich atmosphere to encourage carbonation and drying, but the heaters themselves should never be placed within the scaffold enclosure. The use of any such appliances on a building site requires careful location and supervision.

3.9.3 Dampening-down.

To maintain moist conditions and slow down the rate of drying in hot or windy weather it may be necessary to regularly mist spray the surface of the curing lime material. This is usually done at the end of the day's work, supplemented during the day where necessary. Provision should be made to continue this regime over weekends and public holidays, or other periods when there is no activity on site.

A useful facility for dampening is a ring main hose system, fixed around the scaffold, with valve connections at strategic points to which short lengths of hose may be fixed. An alternative to mains water might be a header tank kept on the scaffold. Hand-held and back-pack sprays are useful for localised dampening and an immediate working area which has dried out too much may be re-dampened by flicking water from a brush. Dampening should be done at low pressure and care must be taken to avoid saturation, since over wetting will wash lime from the new mortar leaving a weakened material. Any surviving material which is to be retained must be carefully protected to avoid it being washed away.

The amount of dampening down required depends on the prevailing weather conditions. No extra dampening down may be required in humid conditions, or in cold or frosty conditions.

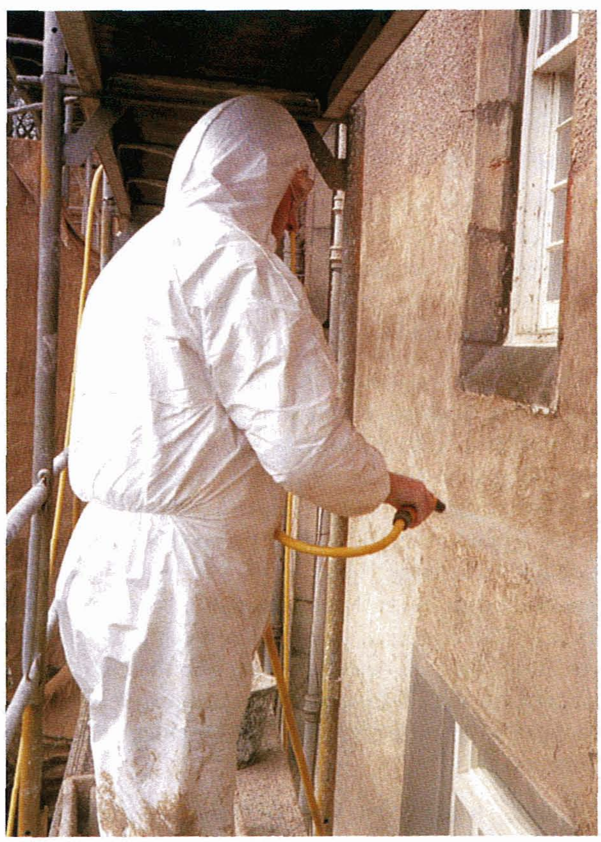


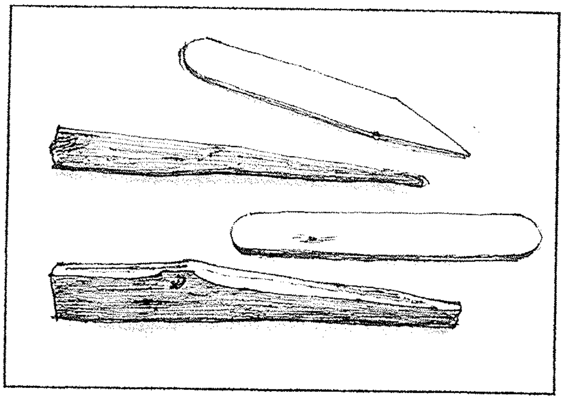
Fig. 32 Dampening-down after harling to control drying out.

3.10 Tools and equipment.

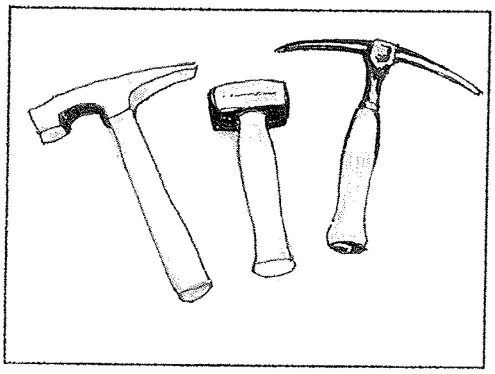
Most of the tools required for the application and finishing of external lime coatings are readily available from specialist suppliers and builders merchants, others will be fashioned by the craftsman to suit particular applications.

TOOLS AND EQUIPMENT

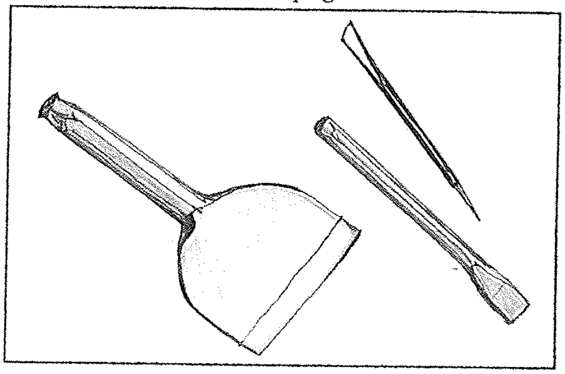
An illustration of the many different tools required to carry out the full range of activities involved in preparation and harling work. Many tools will be fashioned by the craftsman to suit a particular application. Others are readily available from specialist suppliers.



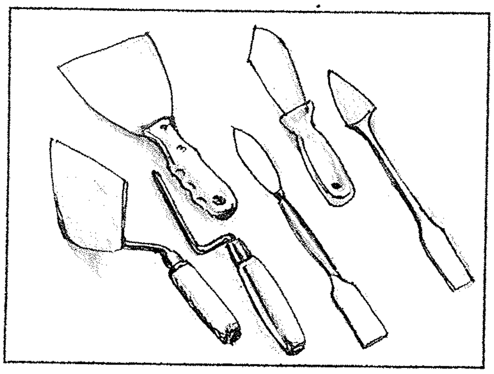
D. Custom made wooden tamping tools



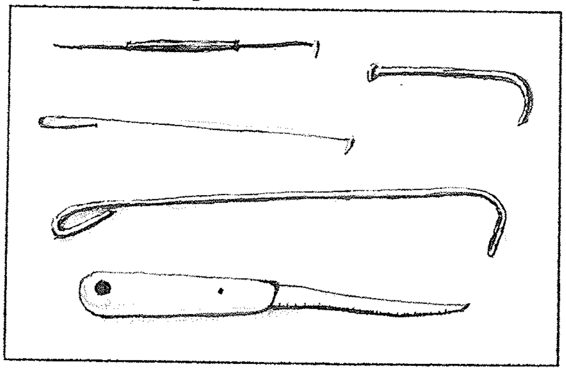
A. Hammers



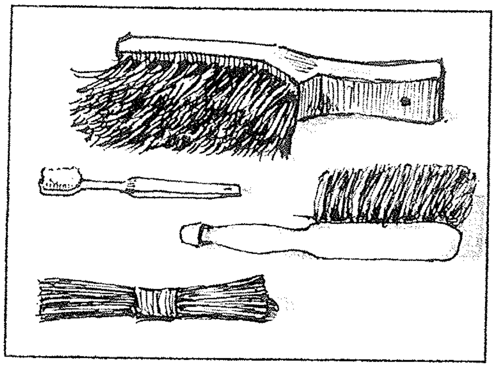
E. Chisels for raking out



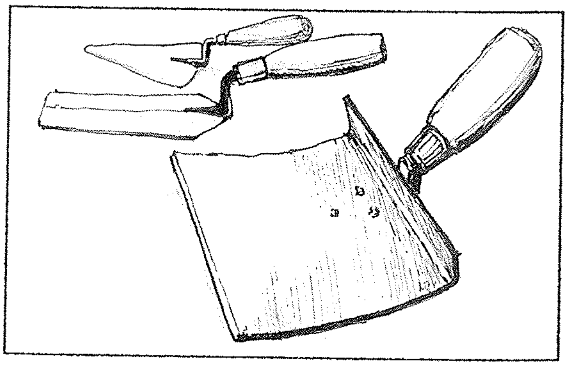
B. Trowels and pointing keys



F. Custom made fine tools for raking out



C. Brushes



G. Harling and margin trowels

Fig 33 Tools and equipment. (1)

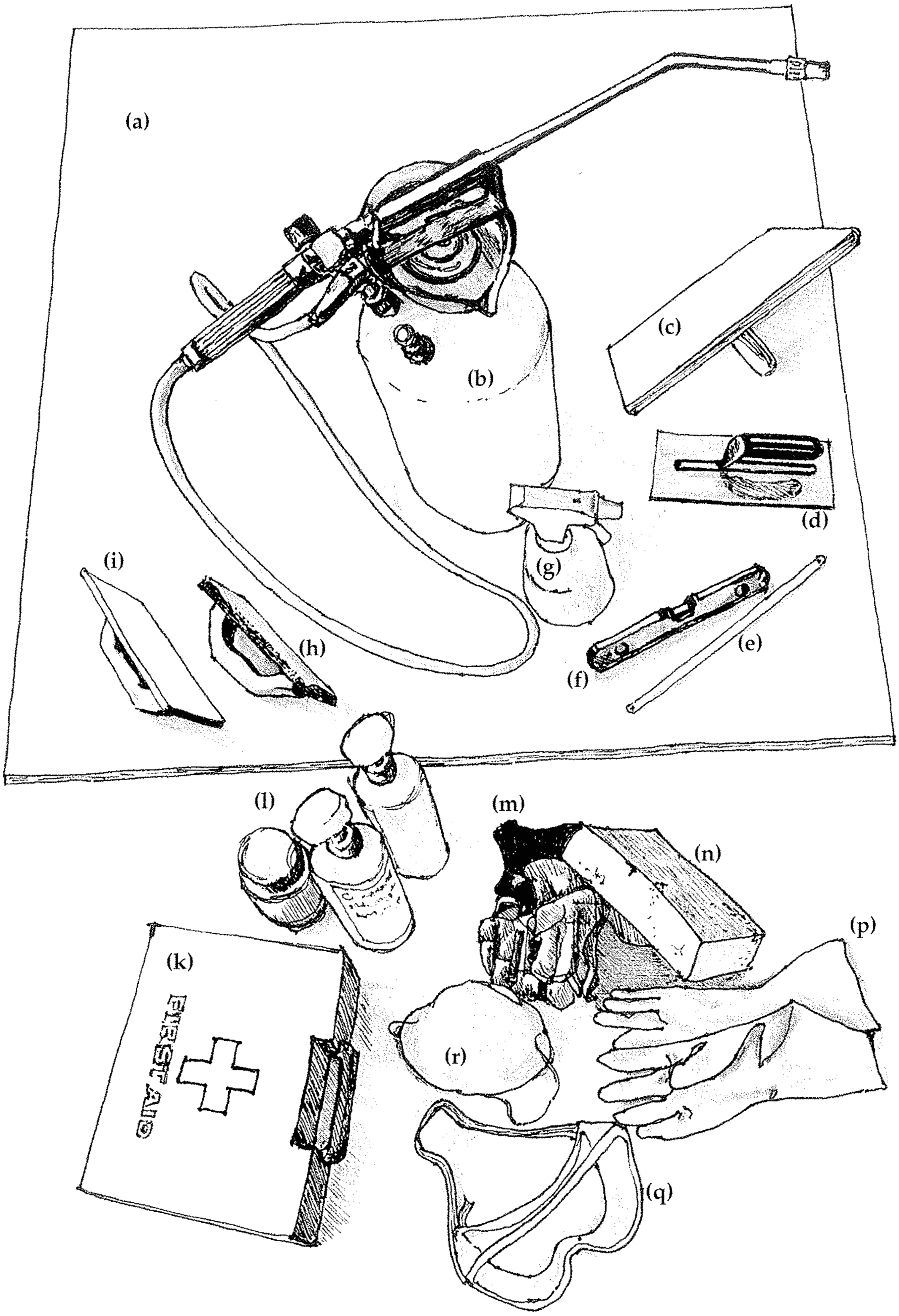


Fig 34 Tools and equipment. (2)
(a) Spot board.
(b) Knapsack sprayer.
(c) Hawk.
(d) Steel harling trowel or float.
(e) Straight edge.
(f) Spirit level.
(g) Mist sprayer.
(h) Sponge float.
(j) Polypropylene float.
(k) First aid kit.
(l) Eye wash.
(m) Gloves.
(n) Sponge.
(p) Rubber gloves.
(q) Goggles.
(r) Face mask.

4. METHODS OF REPAIRING ERODED MASONRY

4.1 The principles of surface repair.

A decision to repair the surface of a wall before application of a lime coating might be taken for two reasons: firstly, in order to eliminate water traps which would cause the newly applied coating to fail and, secondly, to improve the visual appearance and harmonise the wall face. The extent, if any, of appropriate repairs will vary from building to building and will be influenced by the condition and appearance of the building as a whole as well as by the practicalities of achieving a satisfactory repair.

Materials for repair or making good of the background should be chosen to provide a continuity of behaviour with the original. Variations in the degree of porosity or suction of the background will be reflected in the behaviour of the final finish and the introduction of patches of harder materials (including the use of cement patches or cement mortar for making good) should be avoided.

The problems of applying lime coatings to decaying or friable stone surfaces are discussed in 3.3.1. Where the general face of the wall is affected by erosion, decay or loss of mortar and pinnings, to the extent that significant hollows or ledges are formed, some making good, or 'fairing out', of the surface will be required before application of the new coating.

Pinning and galleting, to build out to form a surface to receive a lime coating, should be done as a separate exercise and the material allowed to cure for at least a week before the lime coating itself is applied.

For harling work, the degree to which the wall surface is straightened will require judgement. This will depend on any available historical evidence, the character of construction of the existing wall, and the appearance of any adjacent surfaces, as well as the technical requirements for the new coating. If the erosion is not too deep it may be possible to cast background coats into hollows before the final coats are thrown to a uniform thickness.

Fig.35 Heavily eroded masonry will require repair before harling.

Fig. 36 Determining the extent of repair required to make the wall surface flush.

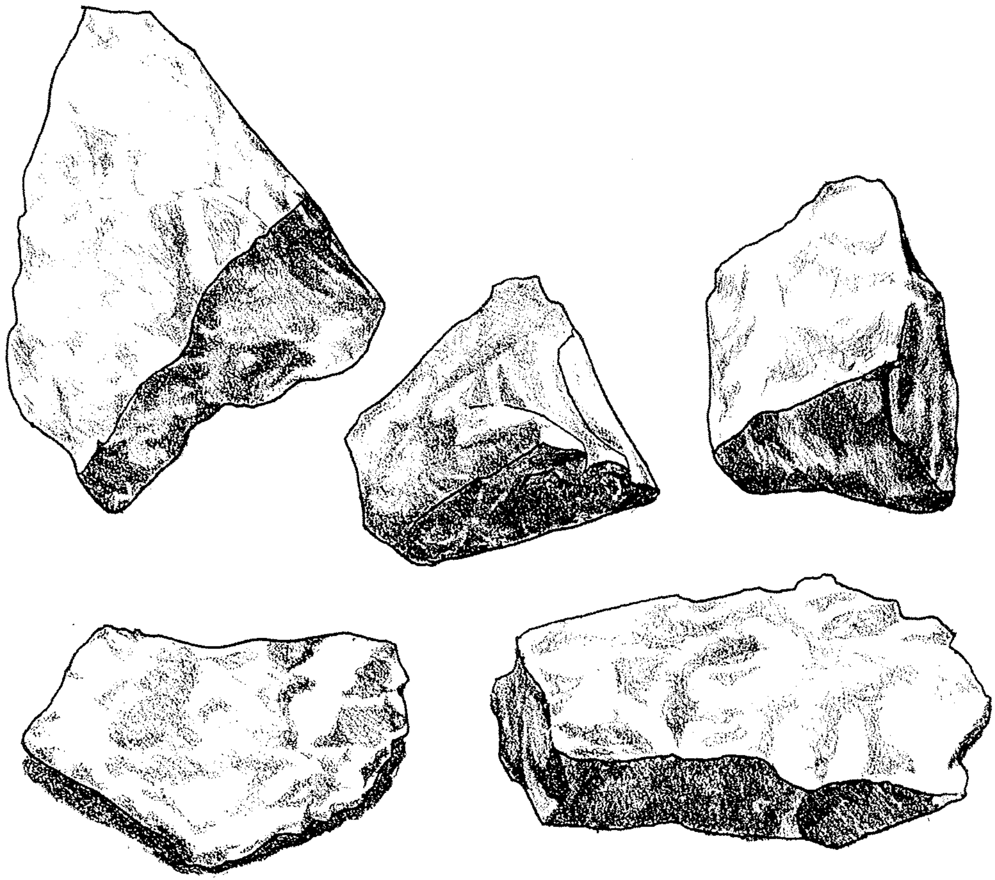


Fig. 37 Diagram D: Showing a range of suitable pinning stones. (Scale is full size).

Fig. 38 Pinnings placed into joints. Note how stones generally make contact with each other.

Fig. 39 Mortar filling out areas of shallow erosion in stones, ready for harling.

Where the wall is to receive a float applied coat the process of preparation should bring the surface to a flat plane, sweetened by eye, not by ruling out, to allow the new coat to be applied to a consistent thickness. Techniques of thick dubbing out, as used with cement mortars, are not appropriate for working with lime mortar.

4.2 Pinning masonry joints.

When removing unsound previous coating or pointing material, any surviving existing pinnings should be retained for re-use. Frequently much of this material will have been lost during previous repairs, and it will be necessary to provide suitable replacement pinnings to adequately pack the joints and fill out areas of surface erosion.

With walls dampened down, pinning stones should be packed tightly into the joints using a stiff pointing mortar, always respecting the original 'build' pattern of stones and joints. Porous pinning stones should be soaked before being placed. Hair may be added to the mortar mix to make it easier to push the mortar back with the pointing tool. The thickness of mortar should not normally exceed 15-20mm and deep joints need to be built out in consecutive layers, allowing the mortar to firm up between applications. The pinnings should be closely spaced, often with stone-to-stone contact to ensure structural integrity and to minimise the amount of mortar used.

Fig. 40 Ashlar masonry suffering from deep erosion.

4.3 Dealing with significantly eroded and uneven surfaces.

Where the wall is to receive a coating of cast on harling the surface profile should avoid abrupt changes of plane, especially where these would act as water traps. Badly eroded stone faces should be 'sweetened out' to the line of adjacent good surfaces using a variety of techniques depending on the nature and extent of the decay.

4.3.1 Shallow erosion.

Relatively shallow areas may be built out with a well-haired lime mortar, with suitably shaped pieces of the pinning material pressed into deeper parts to reduce the volume of mortar. Mortars containing a filler such as crushed soft-fired clay tile aggregate, or other air entraining and pozzolanic material, might also be used for filling out undulations before application of the final coatings.

4.3.2 Deep erosion.

In walls constructed largely of undressed boulders the original construction generally incorporated a mass of pinnings and mortar in the hollows between boulders. This infill is now frequently missing and will require to be made good before the application of lime coatings. Depending on the depth involved and the nature of the masonry, the hollows may be made up by casting in several successive preliminary coats of harling, incorporating pinnings where possible; or by raking out and building pinnings back into the joints to re-

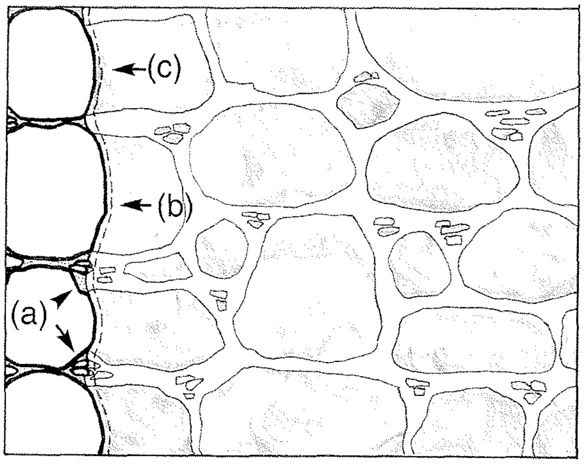


Fig. 41 Diagram E: Minimal fairing out. Section/elevation of prepared wall surface prior to harling. (1)
(a) Pinned up joints recessed behind the line of the high points of the main stones.
(b) Larger surface areas of stone visible after pinning up.
(c) Harling (shown dotted) remains of more or less uniform thickness.

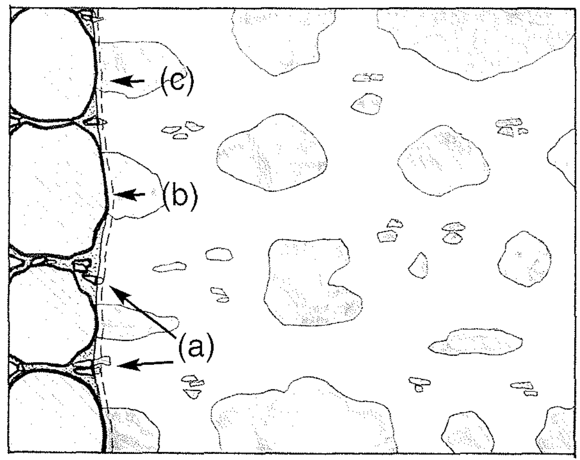


Fig. 42 Diagram F: Full fairing out. Section/elevation of prepared wall surface prior to harling. (2)
(a) Pinned up joints brought more or less flush with the high points of the main stones.
(b) Small surface areas of stone visible after pinning up.
(c) Harling (shown dotted) remains at a uniform thickness.
Note: Pinnings are generally inserted in the horizontal plane into the wall voids.

establish the line of the wall face, before building out with a suitable lime mortar, as described above. This process of achieving an appropriate surface on which to apply the new lime mortar coating is referred to as 'fairing out'.

Areas of deep erosion in the stonework itself generally require careful handling to avoid water traps. The greater thickness of build up that will be required over these areas should be achieved with the use of horizontally bedded pinnings, well bonded into joints wherever possible. *Small* vertically bedded, thin gallets might be required in some situations but these should be avoided as far as possible and, where used, must be well bedded within a sufficient thickness of lime mortar. In any case gallets should be as small as possible: the use of large face bedded gallets should be avoided, as these are significantly more likely to fail if other problems arise.

An effective technique when fairing out uneven surfaces is to use either the higher points of neighbouring stones, or the 'tide mark' left by previous filling, as reference points and fill in between, but without attempting to 'straighten' the overall wall surface. A straight edge can be placed across the area between higher points to check the fairing out, the shorter the straight edge the more overall undulation will be in the wall face. Using this method, undulations in the wall are accepted, while the finished lime coating itself avoids recesses and water traps. The extent of fairing out may vary; in the fullest work the visual result will be a number of stone faces peeking out of a sea of mortar and pinnings, and the surface will appear quite level to the eye. In other cases it may be appropriate to accept a greater degree of overall undulation but always avoiding ledges and water traps.

4.3.3 Indenting and stone replacement.

Where it is clear that repair of a complete stone surface is necessary in regularly jointed masonry, consideration should be given to setting in a stone slip to recreate the original stone face. Factors to be considered when selecting stone for repairs are discussed at 2.3.1. Indented stone slips should be bedded in a lime mortar and are likely to require mechanical fixing, using stainless steel or phosphor bronze pins. On the rare occasions where decay of an individual stone threatens stability of the wall, full cutting out and indenting may be justified, but this in itself could potentially compromise the stability of an old and decaying wall and should be avoided if possible.

4.4 Preparation to receive lime coatings.

On completion of the fairing out, the surface of the mortar should be left with an open texture to encourage carbonation and with a good key in readiness to receive the new lime mortar coating. If there is a significant difference in porosity and suction across the face of the wall (for example after fairing out of a whin wall

Fig. 43 Stonework where some indenting or replacement might be considered before harling.

surface) this should be evened out by the application of a splatterdash coat prior to application of the coating itself.

All loose friable material should be removed from the face (or stabilised as described at 3.8.2) and vegetation eliminated.

To minimise shrinkage of the new material and ensure a good bond it is essential that suction of the substrate is controlled. This will usually involve dampening down but, in the case of impervious masonry, care is required to avoid overwetting. Because it is important to maintain moist conditions, by protection and re-dampening as required, while the new lime coatings cure and carbonate, adequate protective coverings should be in place before the work starts.

5. LIMEWASH FINISHES FOR EXTERNAL LIME COATINGS

This section provides only a general introduction to the use of limewash; further technical guidance will be published in due course. In the meantime specialist advice should be sought if necessary.

5.1 General principles.

Limewash is a traditional external and internal finish for many stone and brick buildings, applied either directly to the masonry surface or, more commonly, to a coating of lime harl or render. It has an important protective function and, in addition, provides a subtle quality of appearance unobtainable with any other finish - modern paint systems cannot replicate the characteristics of traditional limewash.

Limewash is also a common finishing material for clay and earth buildings with or without a lime based coating.

Limewash has the same basic technology as other lime materials and, being vapour permeable, it will allow any moisture that enters to evaporate again, protecting the lime coating or masonry beneath. Limewash is a 'healing' material, capable of repairing any minor shrinkage cracks that may have appeared in the underlying lime coating, and of consolidating or tightening the surface. Correctly applied, limewash is a durable material but, like any other paint system, it requires recoating from time to time. It must also be regarded as 'sacrificial' to a certain extent, and occasional patching and, eventually, full re-limewashing will be needed for the upkeep of the underlying coating of lime harl or render. Investigation of existing limewashed surfaces will often show many different layers of limewash where the building has been maintained over a long period.

It is generally recommended that new lime mortar coatings be completed with at least four, and up to seven coats of limewash. Application, if possible, of a further one or two coats of limewash over the next few years will assist in building up the number of layers and the durability of the coating. Existing sound limewash should not normally need to be removed before re-coating, only loose material need be brushed away, and any lichen or moss growth removed. Ultimately it might be expected that a cycle of 10 or 20 years between successive coats can be achieved, and in some cases considerably longer, although this will depend on local conditions. Expectations of what is an acceptable visual appearance may also determine the frequency of limewashing cycles.

5.2 Types of limewash.

Limewash is a combination of slaked lime and additional water. It is most commonly produced by adding water to slaked lime in the form of lime putty or, alternatively, from first principles by slaking quicklime in excess water. Limewash can also be made from hydraulic lime hydrate for use over a sound background.

5.2.1 Simple limewash.

Basic limewash is made from mature non-hydraulic lime putty and clean water. (It will benefit from being allowed to stand for a period to allow the water to become lime-saturated). Alternatively, lime-water could be whisked into the putty for immediate use. Ready-made limewash made from very finely divided lime particles is also available from specialist suppliers. It has good covering capacity and carbonates readily.

Limewash made up from dry, hydrated, non-hydraulic lime (builder's lime) is unlikely to be successful and is not recommended.

5.2.2 Hydraulic limewash.

A range of limewashes can be produced using the varying characteristics of different hydraulic limes. The hydraulic reaction will take place in the wet limewash and hydraulic lime washes should therefore be used within a few hours of mixing.

5.2.3 Tallow limewash.

The addition of small quantities of tallow (animal fat) to the final coat of limewash will provide added water shedding properties to the coating, but may reduce permeability. Careful thought should therefore be given to the location of tallow limewash. It is normally used on horizontal surfaces such as parapet copings, window cills, etc. Limewash with a high proportion of tallow will often not accept a further coat until the surface has weathered, which can take several years

Fig. 44 Small quantities of tallow are usually added at the slaking stage to ensure good dispersion throughout the limewash.

Traditionally tallow was added at the slaking stage to ensure complete emulsification in the hot mixture. (See Appendix C for Health and Safety information.) The use of modern 'liquid tallow' may not produce the same results.

5.2.4 Casein limewash.

Casein limewash, which incorporates skimmed milk or commercially produced casein, can provide increased weather resistance and greater opacity without reduction in permeability. The casein reacts with lime to form calcium caseinate, which is less soluble than calcium carbonate.

5.2.5 Sanded limewash.

The addition of fine silica sand or marble dust to a limewash allows it to be used as an undercoat to prepare backgrounds that may be too impervious to accept plain limewash. Over suitable backgrounds, sanded limewash undercoats may also increase the durability of the limewash finish. It is generally recommended that no more than 7% sand, by volume of the lime putty content, should be added to the limewash.

5.3 Colour and pigment.

Lime-fast pigments may be incorporated in limewash to provide a coloured finish, serving decorative as well as functional purposes. Natural earth pigments provide the most authentic colours. Modern chemical pigments and dyes are not generally suitable.

It is inadvisable to attempt to colour the body of the lime mortar coating itself with pigments; effective colour mixing is difficult and, during the long drying process, the pigment tends to migrate to the surface of the mortar, causing pattern staining. There is also some evidence that the addition of significant quantities of pigment can adversely affect the pore structure of a lime mortar.

5.3.1 Plain uncoloured limewash.

Without the addition of pigment, limewash will take on the colour of the lime material used, ranging from pure white to pale buff or creamy colours. Much traditional Scottish lime produced off white to cream coloured limewash, although some purer whites are also found.

5.3.2 Earth pigment limewash.

The earth pigments used in limewash in Scotland appear to have been, most commonly, ochres. Other available earth pigments include raw and burnt umber, and raw and burnt sienna, producing mainly yellows,

Fig. 45 The wide range of earth pigments provides a choice of colours.

reds and oranges. Limewash colours from earth pigments are characteristically 'pastel' shades, due to the finite quantities of pigment that can be carried by the limewash. The larger and more varied particle size in traditionally produced earth pigments produced a more vibrant tone than modern processed pigments.

5.3.3 Copperas limewash.

Limewash containing copperas, or sulphate of iron, can produce a range of colours from pale gold to bright orange. As the material comes into contact with the air the sulphate of iron oxidises, turning from a green colour, when first mixed, to a characteristic orange colour (iron oxide) when dry on the wall. Quite deep tones may be achieved. Traditionally, copperas was incorporated in the limewash at the slaking stage, using proportions of up to 100% by weight of dry quicklime for the strongest colour. Although, for long term stability of colour, it appears that the copperas is best added to hot, slaking quicklime, in modern practice it is frequently added to a mature limewash. Trial samples should be prepared to determine the proportions required if the final colour is critical. The strength of colour will also vary with different batches of the sulphate of iron.

5.3.4 Modern cement colours.

Manufactured oxides or liquid dyes produced specifically for colouring cement mortars can, technically, be used, but these are not recommended. They generally have harsher colours that do not replicate traditional character. In some situations, the very fine particle size of manufactured oxides may be found to migrate more than natural pigments, causing a patchy appearance or streaking.

5.4 Application of limewash.

The rules concerning good site practice in preparation, application and protection during curing of lime mortar coatings apply equally to limewash.

5.4.1 The preparation of materials.

To make limewash, lime putty is mixed with sufficient water to achieve a consistency similar to thin cream. Putty should be knocked up before the addition of water and, if possible, freshly made limewash should be allowed to stand for a period of days to allow the water content to become lime-saturated. Thorough whisking is recommended to ensure complete dispersion. If a hydraulic limewash is being made, hydrates should first be run to a slurry before the addition of further water and the limewash should be used within a few hours of mixing.

Fig. 46 Mixing a limewash to ensure an even consistency.

Where tallow or copperas (sulphate of iron) are used, these should normally incorporated at the slaking stage as noted above.

Dry pigments should be measured accurately and are normally blended with warm water before being thoroughly mixed into the limewash. Pigments should be used in concentrations of no more than 7.5% to 10% by weight of the lime putty content of the limewash. (One litre of limewash should contain approximately 0.33 kg of lime putty.) Because the weight of different pigments will vary the actual quantities and strength of colour achievable will vary with different pigments.

As far as possible, all limewash for one job should be batched, combining and inter-mixing all separately measured quantities at the start of the job. Elevations should always be coated in their entirety, ensuring that work stops at logical places where any minor colour change will not be seen. Limewash should be fully agitated throughout application, to prevent settling out of lime, pigment or, where added, sand. If more than one pigment is used thorough agitation is essential to prevent differential settling out.

Fig. 47 Limewash should normally have a thin consistency and be liberally applied. The use of goggles is recommended.

Fig. 48 Working limewash into the surface as it starts to gel.

5.4.2 Preparation of backgrounds.

Surfaces must be properly prepared before the application of limewash. Application of limewash may slow down the carbonation of the underlying coating so new harls and renders should be allowed to cure and carbonate if possible. All wall surfaces should be clean and sound. Suction must be carefully controlled and, on porous backgrounds, the wall surfaces should be thoroughly dampened and allowed to absorb the moisture before the limewash is applied. The surface should then be re-dampened and the limewash itself applied as soon as the water has been absorbed into the surface.

On impervious backgrounds such as whinstone and granite, or on cement, it may be difficult to get limewash to adhere. Sanded limewash or hydraulic limewash may be useful as a first coat on such backgrounds, but samples should be tried before a commitment is made to the use of limewash in these locations.

5.4.3 Techniques of application.

Limewash should be applied in very thin, even coats. Multiple coats are required; four coats would normally be a minimum, with six or seven on new harling. If possible, a further application of two coats should be programmed after a period of weathering and carbonation.

A thick soft, short-bristled brush is used for application, and the limewash worked well into the surface using the blunt end, not the side, of the brush. Over a textured harl coating the first coat of limewash should be applied generously to fill all interstices. Subsequent coats should be applied evenly and well brushed into the surface. On flat surfaces limewash should be applied by brushing well in all directions finishing, if possible, in one direction, and keeping a wet edge throughout the application.

Each coat should be well burnished into the surface with the brush as it starts to 'gel'. A well-burnished limewash has a silky surface texture, and will protect the harling by enabling it to shed water more rapidly whilst still retaining the essential vapour permeability.

Other traditional techniques of limewashing, often directly onto stone, may be found in some parts of Scotland, involving the use of thick limewash that flakes and falls away after a year or so. These traditions are generally associated with rural dairying areas, such as south-west Scotland and parts of Ayrshire, and may derive from the use of limewash to maintain sterile conditions in byres and dairies. In some rural areas the tradition of limewashing survived well into the second half of the 20th century but, using limewash made up from modern dry hydrated lime, the finish was not durable and was applied on an annual basis.

5.4.4 Protection and curing.

The ideal conditions for the application of limewash are warm (not hot) but humid, or even misty weather. Limewash will often require protection, to prevent over-rapid drying by sun and wind, or damage by rain and frost. Provision for protection is similar to that required for lime mortar coatings, although the overall time for curing the limewash will be considerably less, perhaps no more than a few days in favourable conditions. Each coat of limewash must be allowed to dry and cure slowly, normally under protective covers, and must be dampened down before the application of subsequent coats.

5.5 'Industrial' limewash, (also sold as lime paint).

Commercially available limewashes, based on hydraulic lime hydrates with a small percentage of acrylic are now available from some suppliers. These materials, which can also contain accurate quantities of pigment, are packed ready for the addition of a specified volume of water before use. They have a history of use over 15 years or so on the continent. Whilst the stronger colours are not typical of traditional Scottish materials, the softer shades may be useful where site conditions make the use of traditional limewash difficult.

5.6 Other paint systems.

Limewash is the most suitable finish for lime harls and renders, which must be allowed to remain permeable. Impervious, film-forming materials, such as modern 'plastic' paints, should never be applied over lime based harls or renders, as they trap moisture and accelerate the decay of the lime mortar coatings. Modern polymer-based paints, even when described as vapour permeable, are invariably less permeable than limewash.

Provided they are fully permeable, mineral paints can sometimes be compatible with lime mortar backgrounds, but experience shows they do not necessarily have a longer life than limewash. Whilst such paints might sometimes be useful in situations where failure of limewash is caused by unavoidable environmental factors, they will not be successful if used as a substitute for good site practice. The application of mineral paints over old limewash surfaces is not recommended. Mineral paints do not have the subtle variations and responsive qualities in daylight of limewash finishes, and tend to give a flat and unvarying colour.

Fig. 49 Monimail Tower, limewash on a lime harl

Fig. 50 Brodie Castle. New lime harling and limewash.

6. MAINTENANCE AND AFTERCARE

6.1 Basic principles.

Traditional masonry buildings require regular routine and long term maintenance. Along with the routine 'housekeeping' tasks of keeping rhones clear of debris and checking and fixing loose slates, the touching up of any minor degradation of limewash finishes should be normal practice. The service life of a limewashed harl or render can be significantly enhanced by prompt attention to any minor defects, particularly over the first few years. On a domestic scale this can be undertaken very simply by brush application of limewash to minor defects if and when necessary. Limewash can be kept in a re-sealing container for this purpose. Maintenance work to larger buildings will require more planning, but the basic principles of attending to minor defects as early as possible and of gradually building up the limewash coating are equally applicable. An investment in maintenance in the early years will pay off in terms of increasing intervals between re-limewashing over later years. If the possibility arises to undertake a full limewashing of the building within the first two years or so this is likely to be beneficial.

6.2 The way lime coatings behave.

The technology of lime based coatings is discussed at 1.5. Lime mortar coatings and limewash finishes themselves require an environment of good building repair to maintain their decorative and protective qualities. They will be damaged by excessive levels of moisture, particularly by water penetrating behind, or saturating, the coating, as may occur where rainwater goods are not maintained. This damage may be differentiated from actual failures of lime materials, which might typically manifest themselves by the end of the second winter after application, and which may be due to selection of inappropriate materials, or faults in specification, quality of materials, application, protection during curing, or to a combination of these.

Where building details have not been fully resolved, the performance of lime based coatings will be compromised. Even where direct saturation of the coatings does not occur, faults such as poor cope detailing, ineffective roof flashings, inadequate ground drainage and lack of an evaporation zone in hard ground surfaces will lead to degradation of finishes. This can include moss and lichen growth as well as the eventual mechanical breakdown of the coating. Ideally, the base of walls should be provided with an evaporation zone to increase the longevity of the lime coatings.

Other factors such as ground water salts, sea spray, road salting, heavy traffic splash-back, animal fouling and vandalism or other mechanical damage can also reduce the life of lime based coatings and increase the requirement for ongoing repair and maintenance.

The life expectancy of a lime harling or render can be directly influenced by any of the following: -

- Selection or specification of appropriate materials.
- Quality of materials and workmanship.
- Preparation of substrates for coating.
- Building detailing.
- The maintenance regime.
- Local environmental conditions.

The 'sacrificial' nature of lime coatings (and other lime materials) must also be understood. By intention they are designed to be less durable than the masonry to which they are applied (in order to prolong the life of the masonry) and they will eventually decay. Lime materials are renewable at a lower cost and with less intervention to the building than is required for renewal of the masonry itself.

Some freshly quarried sandstones might tend to reject limewash (and other paint finishes) until the 'quarry sap' has dried and any associated efflorescence has ceased. This may be more obvious in some stones than others, and information should be sought from the stone supplier or experienced users before applying limewash to unseasoned, freshly quarried stone. Similarly, previous contamination of secondhand stone can cause breakdown of lime coatings.

6.3 The appearance of lime finishes.

The gradual development of a patina of age should be expected from lime materials, which, unlike most modern paint systems, can be very attractive as they mature and decay. In certain lights limewash finishes may appear to almost 'glow', particularly in early morning or evening light. Lime coatings more faithfully reproduce historic finishes than modern renders, wet dash and paint systems and appear aesthetically more pleasing as a result. Limewash, particularly coloured limewash, has a lively finish which reacts to weather conditions, appearing darker while wet, but returning to its original colour when dry. Some degree of pattern staining may develop at points of repeated moisture movement. Depending on local conditions other soiling patterns may be observed, as on any similar traditional building; these are not directly related to the use of lime finishes, but may be more obvious on a light coloured, newly limewashed building than on a darker stone surface.

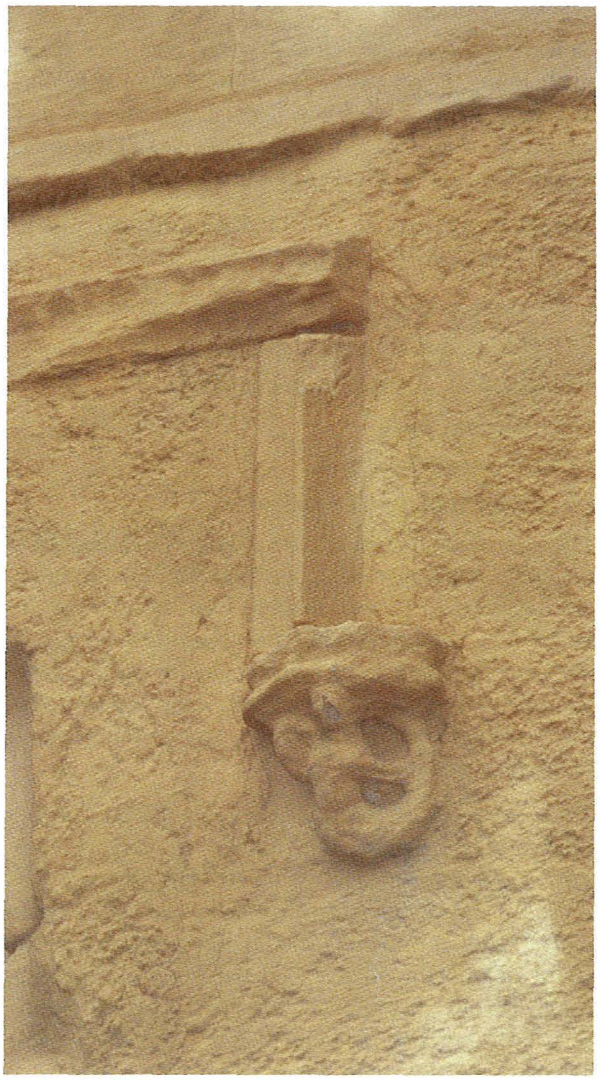


Fig. 51 Lime harling showing colour changes when wet.

Depending on the types and grades of sands, limes and pigments used, a wide range of finishes and textures can be achieved, from limewashing directly onto 'flush pointed' masonry walling or details to limewashing over a strongly textured harl, and these finishes and textures will each tend to weather slightly differently.

Although it is possible to achieve vibrant coloured limewashes, it is not possible to achieve very deep shades, other than the strong orange colours attained by the use of copperas (sulphate of iron) traditional in parts of the Lothians. Traditionally, many limewashes were naturally tinted with minerals intrinsic to the original limestone, producing a range of pale ochre or off white shades. Local earth or mineral colours could also be added and, by their very nature, produced earthy tones from off white to a variety of shades of yellow, pink and terracotta. Importantly, limewashes are not degraded by ultra-violet light (like many other paint systems) and colours derived from oxide-based pigments do not fade or break up.

6.4 Maintenance guidelines.

As with other aspects of building maintenance, a planned approach is needed for the care of external lime coatings and finishes. Efficient rainwater disposal for the building must be provided, as saturation of the lime mortar and finishes will make them vulnerable to frost action, as well as causing staining and supporting the growth of vegetation. Maintenance of rainwater disposal systems and ensuring free draining well ventilated areas at ground level are the most important aspects of maintaining external lime coatings and finishes.

In situations of extreme traffic pollution, or where abrasion, vandals or animals may physically damage coatings, additional maintenance may be necessary in the form of physical patching or replacement of damaged areas.

Any subsequent building works that affect the exterior of the building must consider and respect the technology and reasons for use of the lime coating. New materials and treatments must be compatible with the existing, and should be as close to the original specification as possible.

As with any type of painted finish, re-application of the limewash will be required at intervals. After initial application, which might comprise four or more thin coats applied in a short space of time, a period of one or two years weathering is often allowed before application of a further two or more thin coats. Very little long term performance data is available from the UK at present, as the reinstatement of external lime coatings and finishes goes back only 15 to 20 years. However, from observation of Scandinavian practice, where lime coatings with limewash finishes are more commonly applied in urban environments, it appears that the build up of multiple thin coats of limewash in the first few years allows intervals between re-application to be gradually increased to 10 or 15 years or more in the longer term. As well as sealing hairline cracks and increasing the total number of coats applied, this provides the opportunity to monitor the progress of the underlying lime mortar coating and remedy any problem areas. Applied correctly, every application of limewash will improve the quality and durability of the finish. A long term programme of re-limewashing will greatly prolong the life span of external lime coatings, as each successive application improves the stability of what is already there. As with any external painted finish, the length of time between re-coating will be dependent on local environmental conditions, as well as building detailing, workmanship and maintenance.

6.5 Maintenance techniques.

Any attention required to the lime mortar coating itself, whether a harl or a flat rendered coating, is likely to take the form of minor repairs. The basic techniques of repair or renewal as described in 3.8 are equally applicable to the ongoing maintenance of lime mortar coatings. Any minor defects should be dealt with as soon as possible, by careful patching and/or the application of limewash. Effective maintenance of the limewash finish is important and, like any other paint type finish, recoating will be required at intervals. Before re-coating with limewash, wall surfaces should be gently brushed and washed down to remove loose material and dampened to control suction (the suction exerted by multiple layers of limewash is considerable). Minor lichen growth may sometimes be retarded by the application of limewash and, if a regular programme of limewashing is planned, minor regrowth might be acceptable in some situations. More established and vigorous growths will definitely require treatment with an appropriate biocide, (See Technical Advice Note 10, *Biological Growth on Sandstone Buildings: Control and Treatment*) followed by careful physical removal, before the application of limewash. The application of any form of external paint type finish to a building is always dependent to a certain extent on weather conditions, and limewash is no exception. Routine re-application of limewash to the wall faces should be undertaken in cool moist weather if possible, avoiding direct sun on the newly coated wall face. As the limewash builds up over the years the sensitivity of the new coating to weather conditions will diminish, but rapid drying or immediate soaking should be avoided as far as possible.

Re-coating of tallow, or oil bound, limewash may not be possible within a few years of application, depending on the rate of weathering of the surface.

Fig. 52 Identify problem areas such as at chimneys, wallheads, below skews and window cills.

Fig. 53 Additional attention will be required to maintenance at vulnerable details such as harled crowsteps.

7. SPECIFYING EXTERNAL LIME COATINGS

7.1 General principles of specifying.

Detailed specification of materials and working practices is essential for the application of lime based coatings, given the current lack of site expertise and understanding of traditional materials and techniques. The specification should clearly set out the materials to be used, the standards of finish required and the means of achieving them.

Specification of materials and techniques requires an assessment of the building's construction, condition and context. Evidence of original techniques and finishes can provide important information that should be used in specifying repair or replacement work. Materials specified must be *appropriate* to the building in question, to the current environmental conditions and to the context in which the building is situated. To specify a mortar, a range of limes, aggregates and other ingredients are available from which to select the most appropriate materials. It is seldom feasible to use standard or model specifications.

The process of specification is not confined to materials. Well-chosen lime materials may be compromised by building defects that remain un-rectified, by lack of skill in application, and by poor site practices, such as failure to protect work during the carbonation period.

Consideration must be given at an early stage to the likely timing and programming of the work. This will include the availability of materials and labour, as well as funding, and the weather conditions that are likely to be encountered.

7.2 Investigation.

The process of specification should begin with a detailed investigation to establish the nature and condition of existing finishes and their masonry background, the extent of work required, the site context, and the likely seasonal weather conditions. The extent of investigation undertaken will vary, but gaining a real understanding of the situation before deciding on the solution will greatly enhance the likelihood of success.

The nature of the masonry or background, including stone type, its condition, and the method and character of its construction should all be established. The strength and porosity of the background, and the degree of suction it will exert on new lime based materials, should be assessed. Areas of decay, such as spalling of exposed stone faces and decay at joints and beds, should be noted. Reasons for the decay should be considered, including inappropriate previous works or alterations, inappropriate building details, failing building components, inadvertent changes in adjacent building construction, and inappropriate treatments such as masonry paint and hard cementitious renders. The condition and characteristics of existing lime coatings should be assessed, using laboratory analysis techniques where necessary, to identify the original methods of production, mix proportions and lime and aggregate characteristics.

Weather and other conditions that may affect the finished work, such as prevailing winds, maritime positions, orientation and the building's context, should be considered. Problems of local environment, or context, might include the salting of roads, proximity of road traffic, periodic flooding and possible vandalism. A check for any existing soiling patterns will identify areas of inherent water collection or run-off that will have to be dealt with and faulty building detailing or maintenance that may have aggravated the decay.

7.2.1 The extent of work required.

Investigation should determine the extent of work required, and appraise the condition of old lime coatings where they remain. Surviving original materials have historic value and should be conserved wherever possible.

Hard cement render or pointing and finishes such as masonry paint, oil paint and silicone treatment should usually be removed, although removal without damaging the underlying stonework may sometimes prove difficult. If the process of removal would cause too much damage, consideration might be given to leaving a cement render in place and delaying re-harling. Methods of removal should be carefully considered, and written into specifications, if necessary after trials of the possible alternatives. It is inadvisable to use lime materials to patch cement based materials, as they would rapidly decay due to the differences in permeability and moisture movement.

Because it is often difficult to quantify the extent of, or exact technical solution to, work to historic buildings before the job is underway flexibility should be incorporated into the procedures where possible.

7.2.2 Matching surviving materials.

If indenting or other surface repairs are required, information should be provided on the type of stone and mortar to be used to ensure that overall porosity and suction of the background remain consistent. Replacement pinnings also need to be specified and information will be required on the type of material and the size and methods of placement. Normally pinnings will be of a stone compatible with the original masonry although, for work with impervious stone types, a more permeable material may sometimes be appropriate.

Where historic lime finishes survive, they should be examined, and the information gathered should be used to prepare the specification of repair or replacement materials. A visual appraisal will assess the basic characteristics. The texture of finish, throwing patterns, colour, thickness, general character of aggregate, and inclusion of materials like shell should all be noted.

This would normally be followed by mortar analysis by an appropriate specialist conservation laboratory. As far as possible samples for analysis should be taken from material that will, in any case, require renewal. An intact sample through the full thickness of coats is the most useful. The laboratory should report on the structure of the mortar, its constituent materials (i.e. type of lime, character and grading of aggregate, presence of other ingredients) and their relative proportions, and the probable method of production of the original mortar.

7.3 Specifying materials.

Where possible, the specification of new finishes should match surviving historic lime coatings or reflect local character and tradition. Exact matching is most likely to be critical when patching in to surviving historic material. The specification of appropriate repair or replacement materials is important both for appearance and technical performance.

Information gained from mortar analysis may not directly translate into a repair specification, since the present-day site context and the condition of the masonry may place different requirements on the new work. As a rule, coating materials should be less dense and more permeable than the substrate, but should also be suitably durable for the exposure and location. Appraisal of these factors is essential to establish the performance criteria required of the new lime coating, and will assist in the specification of appropriate lime, sand and other materials to be included in the mortar mix.

Where exposure conditions vary within the context of one building, or where problem areas cannot be avoided, it may be necessary to vary the specification accordingly, using more hydraulic, or other special mixes for particular localised areas or features. For more detailed guidance on specifying mortar mixes see TAN 1, *'Preparation and Use of Lime Mortars'*.

Parameters which will affect the specification of new lime based external finishes include:-

7.3.1 The nature and condition of the substrate.

Specification of the mortar mix for external lime coatings on masonry backgrounds will be influenced both by the geological nature of the masonry and by its local context and condition.

Sound masonry.

For sound and durable sandstones, specification of new lime based coatings can potentially encompass a range of mortar strengths, depending on the specific job requirements. However, climatic conditions in Scotland, both during the curing period and over the service life of the coating, can be particularly demanding and, where appropriate, specification of a feebly to moderately hydraulic mortar will probably provide the best solution.

Most of the igneous and metamorphic stones, such as granite and whin, are relatively impervious and moderately hydraulic lime materials might be specified without damage to the stone. The initial set in these materials is advantageous when coating denser stones. Dense stones provide minimal suction and, if necessary, adhesion can be improved by specifying a 'splatterdash' coat of hydraulic lime mortar prior to the harl or render.

Decayed or friable masonry.

For methods of repairing eroded masonry, see chapter 4. Lime coatings for very porous or decayed masonry are likely to require softer mixes, such as traditional feebly hydraulic lime mortars, since harder materials would not adhere well and would be damaging to the underlying masonry. The specification of mortar coatings for soft or poor quality stonework in exposed locations will always present problems. Special mixes incorporating fine limestone aggregate or crushed brick and brickdust may prove more durable than simple lime mortar mixes, without sacrificing their intrinsic permeability.

Clay bonded walls and mass clay walling.

Specifications for lime coatings for clay mortared walls will almost always be based on a non- to feebly hydraulic mortar, since there is a specific requirement for the mortar to be able to dry out readily. In the case of mass clay walling this requirement is paramount and nothing stronger than a traditional feebly hydraulic mortar should be specified.

Brick substrates.

The specification of lime based coatings for brickwork follows the same basic principles as for masonry. The strength of the mortar should never be greater than that of the substrate and the local context and exposure must be taken into account. For soft 18th century brickwork set in lime mortar any lime mortar coating should be of a similar strength, probably non hydraulic to feebly hydraulic. For denser harder bricks, including modern brickwork, a moderately hydraulic mix can often be specified.

Concrete blocks.

The strength of lime mortar specified for coating modern concrete blockwork is normally within the range of moderately to eminently hydraulic.

7.3.2 The degree of exposure.

Traditional feebly hydraulic lime mortars will be appropriate for harling in many situations, although buildings in areas of extreme weather conditions and maritime situations will generally require more durable materials to be specified. Hydraulic lime mortars can generally withstand higher and more continuous moisture levels, and so are useful in situations of greater exposure. However, eminently hydraulic lime coatings are generally more dense, and may be less permeable than those based on non-hydraulic or traditional feebly hydraulic limes and are, potentially, more harmful to porous or friable masonry.

If the use of a hydraulic lime is inappropriate, durability may be enhanced by careful selection of other mortar components, such as brick dust (which provides a pozzolanic set) or finely crushed limestone aggregate, without causing loss of permeability in the finish.

7.3.3 Problem areas / local context.

Particular areas of a building may experience greater or lesser degrees of exposure, or may retain dampness due to their inherent design. Persistent or high levels of dampness will endanger non- or feebly hydraulic lime materials, making them vulnerable to frost damage. Water penetration is a common problem at wall-heads, parapets, chimneys, and below skews. The vulnerable area of wall surface just above ground level can suffer from rising damp or water splashed up from hard adjacent ground surfaces, exaggerated by salted roads and passing traffic. Impervious barriers within the structure can cause concentrations of moisture in the masonry. (For example, ground moisture will be concentrated below a damp proof course).

In order to remove these sources of excess moisture the necessary building repairs should be specified and carried out before the application of lime based finishes. Some common building detailing problems are discussed at 7.4, below.

Within the context of one building it may be appropriate for the specification of external lime based coatings to encompass several variations. Mixes for use at chimney heads, parapets and other areas of severe exposure may be stronger than those required for protected wall surfaces.

West facing gables often present problems, since the lime coating may become saturated immediately before severe freezing. Other vulnerable areas include wall surfaces immediately below gable skews and the zone immediately above ground level. The application of a surface coating to both faces of a free standing wall, such as a garden wall or parapet, is unlikely to be successful.

7.3.4 Availability of materials and skills.

Lime based materials are becoming increasingly available and identification and specification of appropriate materials does not generally present a problem for routine work. Lime may be purchased as traditionally slaked putty (English non-hydraulic lime) or as dry powder (imported and English hydraulic limes). Ready mixed mortars (coarse stuff), based on non-hydraulic putty and a selection of sands, are also available. These may be designed for use on their own or, alternatively, for gauging on site with hydraulic lime.

Where special matching is required careful choice of materials will be needed. Information on available aggregates can be sought from the Historic Scotland database of aggregates. No Scottish limes are currently in production, but acceptable matches can sometimes be achieved by blending commercially available English and imported materials. The one-off production of lime from appropriate Scottish limestone sources is sometimes possible where specific matching is required. (Contact the Scottish Lime Centre Trust).

Although the final performance of the mortar for external coatings will be the main criteria for specification, decisions will also be required on the extent of site preparation of mortar, versus use of ready mixed materials, and the level of site skills likely to be available, in order to finalise the specification of materials.

7.3.5 Other materials.

The specification should include information on the type of biocide, if any, to be used and on materials for 'fairing out' or making good the wall surface, if required, prior to application of the lime coating itself.

7.3.6 Specifying limewash.

Limewash is commonly specified as a finish to external lime coatings and, in some areas, directly onto stonework. In addition to its visual qualities it has a protective role. The selection and specification of limewash should be based on the character, condition and context of the surface to which it will be applied. For details on the production and use of limewash refer to chapter 5. Normally limewash is based on non-hydraulic lime putty but, for use over a moderately hydraulic harl, limewash can also be made from feebly or moderately hydraulic lime. Fine sand may be incorporated, or it may be gauged with traditional 'water-proofing' materials such as tallow or linseed oil. Limewash specifications that increase durability and waterproofing will also tend to decrease permeability. The general rule is to make limewashes more permeable than their background and the final coats should never be stronger than the preceding ones. Non-hydraulic lime harls and renders should therefore not be coated with a hydraulic limewash.

The specification of a modern 'modified' limewash (also described by the manufacturer as lime paint) may be appropriate where additional durability is required and there is no specific requirement for matching to historic materials.

7.3.7 New building work.

The specification of external lime coatings on new building work will normally be based on the same criteria as for existing buildings. It is preferable for any new masonry structures, which are to be lime harled or rendered, to be built with lime based mortars rather than cement. Cement mortar joints may encourage the retention of moisture in the lime coating, showing through on the finished work, and salts from cement mortar may damage the lime coating.

Regular joints in concrete blockwork may sometimes 'ghost' through a traditional lime harl or render. This occurs most often where mortar in the joints was not fully dry before the coating was applied, or where pointing is recessed. The likelihood of 'ghosting' may be reduced by preceding the harling or render with a 'splatterdash' coat of a moderately hydraulic lime mix. This should be kept thin and lightly pressed back to produce an even surface. Alternatively a moderately hydraulic render coat may be applied to the blockwork, keyed and fully cured before the application of a lime harling. The problems of applying external trowelled lime renders are discussed in 3.6.

7.4 Building repair and detailing.

An important part of the specification and repair process is the correct appraisal, and rectifying, of building defects that would be detrimental to the success of new lime coatings. Persistent dampness hinders the carbonation of new lime materials and exposes them to frost damage. Faulty rainwater goods, open joints to copings, etc, must be repaired prior to

Fig. 54 Thorough inspection is required to appraise building defects.

any new lime work. Regular maintenance thereafter is also essential.

Lime coating materials will very quickly show up any soiling patterns due to faulty design and construction. Some existing building details may be inherently defective, and it will be necessary to consider altering them. This may involve adding or altering coping stones and skew details, or fixing protective lead flashings over projecting mouldings. The alteration of construction details in a listed building will require statutory consent.

Problems arising from rising damp, salt efflorescence, and water splashing up onto the base of a new lime coating, may be reduced by forming a channel filled with free-draining material at the base of the wall and by keeping the area free of planting.

7.4.1 Edge detailing of lime coatings.

As discussed in 3.4.3, the detailing of junctions between harling and adjacent materials is critical to the success of the harling as a whole. The implications of existing details should be considered and modifications specified if necessary or appropriate. The specification, or accompanying detail drawings, should clearly indicate the required detailing at junctions between lime based coatings and other building elements. The lime coating itself must also be designed to shed water effectively.

Fig. 55 Good detailing will assist in prolonging the life of lime coatings.

7.5 Specifying site practice.

As discussed in chapter 3, good site practice is critical when using lime mortars, including those for external coatings, and the specification should clearly state the required standards of work. It should include information on the handling and storage of materials, protection of adjacent building fabric, the employment of appropriate trade skills and practices, and health and safety. The provision of appropriate access scaffolding, the necessary services, and adequate protection to work in progress and to completed work, should be highlighted. Aspects of site practice are discussed below.

7.5.1 Codes of practice.

There are two formal standards applicable to the use of renders and harls. These are BS8000, Part 10 *'Code of practice for plastering and rendering'*, and BS6262, 1991 *'Code of practice for external renderings'*. Appropriate standards for general site working practices and requirements for protection of new mortars included in these codes are equally applicable to lime, as well as cement mortars. In practice, however, these standards are rarely implemented on modern building sites, as cement based materials are, in the short term, more tolerant of short-cuts and errors.

A specification for external lime coatings should make it clear that adherence to these standards of site practice is a *minimum* requirement. Specifications will generally also need to include for more comprehensive measures depending on the type of work, the exposure of the site and the time of year in which the work is being carried out.

In terms of materials, mortar mixes and site skills however, much of what these standards contain is not applicable to traditional lime works. The requirements of BS7913, 1998, *'Guide to the principles of the conservation of historic buildings'*, should be taken into account in this context.

Information on the need for good quality control and good practice in health and safety should also be included in the specification.

7.5.2 Preparation and programming.

Adequate forward planning is required. As discussed at 7.2, this will involve the proper investigation and evaluation of the building before specification, including analysis of original materials, preparation or ordering of new materials, programming work in conjunction with other trades, preparation of sample panels, obtaining statutory consents, and consideration of the availability and timing of funding.

The availability of suitably skilled contractors will also have to be taken into account, and may require planning of at least a year ahead. (See 7.5.7 for comments on selection of contractors).

Timing of the works is critical to their likely success. Outwith the traditional working season of April to September, new lime materials will be vulnerable to damage by rain or frost unless a fully controlled protective environment can be created, and at other times of the year rapid drying by sun or wind can present a problem. (See 3.9)

7.5.3 Ordering materials.

If mortars are to be made up by the contractor, programming must provide sufficient time, in advance of the actual harling or render work, for the production and, where appropriate, the maturing of putty or mortars. Consideration should be given to the need for storage space for the materials during this period.

Alternatively, ready-made mortars may be obtained from a specialist supplier. The availability of supplies should be confirmed, and in some cases materials may have to be ordered in advance of appointing a contractor.

7.5.4 The need for protection.

Even though, under normal contract conditions, it is the responsibility of the contractor to make provision for protection of the works, it is recommended that a specification for traditional lime working should include information on the extent and type of protection required and on the implications of failure to adequately protect the new lime works. The specification should make clear the need for a suitable, normally a protected, environment in order to achieve adequate curing, and will usually describe appropriate means of achieving this. (See 3.9).

Attention should also be drawn to the need for care in the handling of rainwater disposal during the works. Timing of the fixing of rainwater goods should be carefully considered. Fixing of brackets, holderbatts, and other supports is advisable prior to the application of lime based coatings, to avoid later damage to finished work. It may be preferable to fix rhones and conductors after the harling or rendering is finished, to allow easier application of the finishes, but temporary rainwater collection or water spouts must be installed in the meantime to protect the work from accidental water damage.

Fig. 56 Outer protection to the scaffold. Note also the water distribution pipework.

Protection of adjacent building fabric and other surfaces from stray lime materials is required, particularly throughout harling and limewashing operations. Openings can be shielded with plastic sheeting on wooden frames, and exposed masonry and down pipes should have plastic sheeting taped in place.

Plastic sheeting laid at the base of the wall will catch any surplus material, keep the ground clean and protect nearby features and plants. When existing finishes are being removed, this sheeting may be needed to contain dust and shards of render. Particular attention should be paid to the need to keep air vents, or other evaporation zones at the base of the wall, free from a build-up of debris, and provision should be made in the specification for reinstating an effective evaporation zone adjacent to the walls on completion of the works.

7.5.5 Specifying scaffolding and access.

Scaffold is often fixed by specialist subcontractors at the start of the contract for use by various trades and, if the special requirements necessary for the successful application of traditional lime coatings are not taken into account at this stage, problems can occur later. The inclusion in the specification (perhaps in the preliminaries section) of information on scaffold and access requirements is advisable.

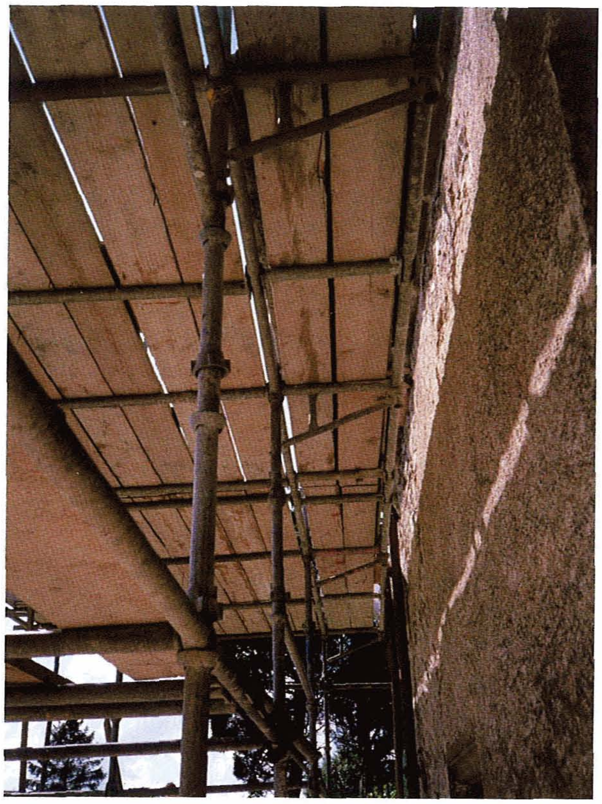


Fig. 57 Scaffolding with correctly placed uprights and removable inner boards.

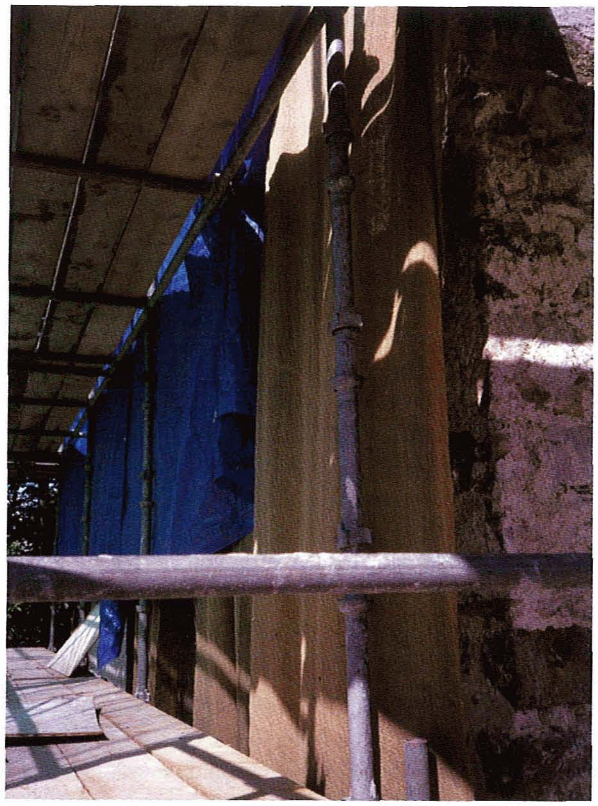


Fig. 58 A close covering of hessian and plastic sheeting to protect new harling in warm weather.

Ill-considered scaffolding often compromises the application of lime coatings. Uprights fixed too close to the wall can inhibit the application of cast or trowelled finishes and thus may prevent completion of an area in a single operation. This can result in visible 'lift lines' and the appearance of unexpected surface patterns. A clear working space may be achieved by incorporating 2 or 3 removable boards to the inside of the 4- or 5-boarded platform normally allowed for general-purpose scaffolding. These inner boards may be lifted away to allow harling to be cast onto this area, and also to allow free-hanging covers to protect the work as it progresses. In addition, a two-stage hop-up will be required to provide the tradesmen with improved access to all parts of the wall.

Where the scaffold is required to serve other trades, special arrangements may be needed to comply with current health and safety requirements, particularly with regard to any spaces between the wall face and scaffolding boards.

The scaffolding should not be in contact with the surface to be harled or rendered, and the location of any positive fixings should be carefully considered to avoid damage to historic masonry.

Protective sheeting may impose additional wind loads on the scaffold, or could cause damage to newly placed finishes if inadequately secured.

Provision should be made for any temporary services, including the siting of water tanks or a hose system for dampening down walls prior to harling, and an electrical supply. A high standard of task lighting will be required in an enclosed scaffold.

7.5.6 Health & safety considerations.

The health and safety implications of specifications must be highlighted at the design stage in risk assessments, and working practice with lime materials should be fully evaluated in contractors' methods statements. The Construction Design and Management (CDM) Regulations 1994 set out procedures for this. Under the Control of Substances Hazardous to Health (COSHH) Regulations, material suppliers must provide health and safety data sheets with their materials.

Lime is an alkaline material and can be harmful to the skin or eyes although, as with most common building materials, lime products can be used without danger provided a few simple precautions are taken. A suggested guide to safe working practice is outlined in Appendix C.

7.5.7 Specifying workmanship.

The standard of workmanship and methods employed in applying and finishing external lime coatings will have considerable effect on the visual quality and technical viability of the work.

Although there are a number of experienced tradesmen available to undertake conservation and repair work to traditional buildings, in general there is, currently, an overall shortage of traditional craft skills.

In order to establish realistic pricing for lime harling or rendering, full details of required site practice and procedures should be included in specifications. Competitive tendering by contractors who are inexperienced in traditional work frequently results in unrealistic pricing. This is likely to lead to lower standards of work, or even significant failures, and can cause irreversible damage to historic buildings. Full specification of the requirements for workmanship and protection can also provide support for specialist sub contractors in their dealings with a main contractor, who may not fully appreciate the implications of lime based works.

For historic buildings, and other buildings of traditional construction, only tradesmen who can demonstrate the necessary skill and experience should be employed. At an early stage in the specifying process enquiries should be made to establish the experience of the available tradesmen. In some cases it may be necessary to allow for additional training of the workforce within the scope of the contract. In order to properly assess a contractor's capabilities, it may be appropriate to call for specific method statements on proposed working practices as part of the tender process.

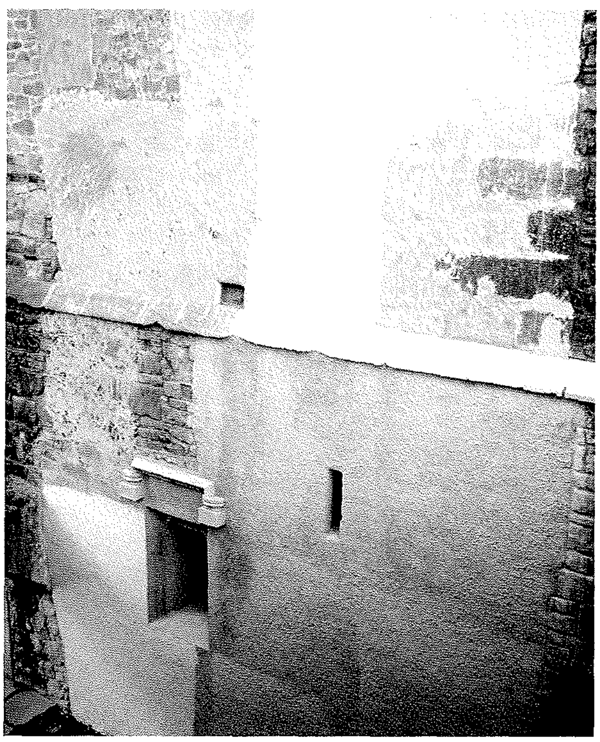


Fig. 59 Sample panels of harling and limewash.

7.5.8 The need for sample panels.

At an early stage in the contract, or before the start of the contract, sample panels may be required to clarify and finalise aspects of the specification. Final decisions may need to be taken on the detail of surface finish, colour of limewash etc. Trials may also be needed to determine other factors, such as expected times for curing, and the requirements for protection.

In addition, the preparation of contractors' sample panels, to define the standards of workmanship and finish, is usually essential. Sample panels should be specified for each stage of the work: removing existing renders, 'fairing out' wall surfaces, and for applying harl or render and limewash. Once agreed they should be kept for reference and quality control throughout that stage of the work.

Where small areas of harling or render are to be 'patched in' to existing sound work, the existing work may serve as a control sample.

With an inexperienced contractor it may be necessary to include for an initial period of familiarisation or training at the start of a project, using trial sample panels to develop satisfactory working techniques.

7.5.9 Supervision on site.

A well-written and comprehensive specification alone is not a guarantee of good work on site. It is essential that day-to-day supervision should be provided by someone with adequate knowledge and experience, with an understanding of the properties and limitations of traditional materials, and of the skills and requirements of traditional building trades. The requirement for this level of supervision should be made clear in the specification.

Records should be kept by the person responsible for supervision, in the form of a site diary, noting the progress of the work, weather conditions and any other relevant events, including agreed changes to the original specifications. At the end of the project the building owner or the specifier should retain the diary for future reference. A re-evaluation of the original intentions of the work, compared with what was actually undertaken, will provide a useful starting point for future projects.

7.6 A structure for specifications.

Specifications should always be written *specifically* for the individual requirements of the building. The use of all-embracing standardised specifications, from which the contractor must chose those items applicable to the contract, is not appropriate for this type of work. A suggested outline structure is included at Appendix D.

APPENDIX A
TECHNIQUES OF APPLICATION FOR EXTERNAL LIME COATINGS.

A. LIME HARL OR FLAT RENDER: PREPARATION

Photographs 60 to 65 illustrate the process of preparing the wall surface prior to the start of lime mortar works.

Fig. 60 Removing defective harling.

Fig. 61 Thickness of inappropriate former repairs to harling.

Fig. 62 Wall following removal of defective harling.

Fig. 63 Removing loose mortar from joints.

Fig. 64 Washing down the surface to remove any loose material.

Fig. 65 Brushing down to remove any dust.

Photographs 66 to 69 illustrate the process of filling joints and bringing deeper areas of erosion forward to avoid formation of ledges, prior to application of harl or render.

Fig. 66 Pushing pinnings into wide and eroded joints.

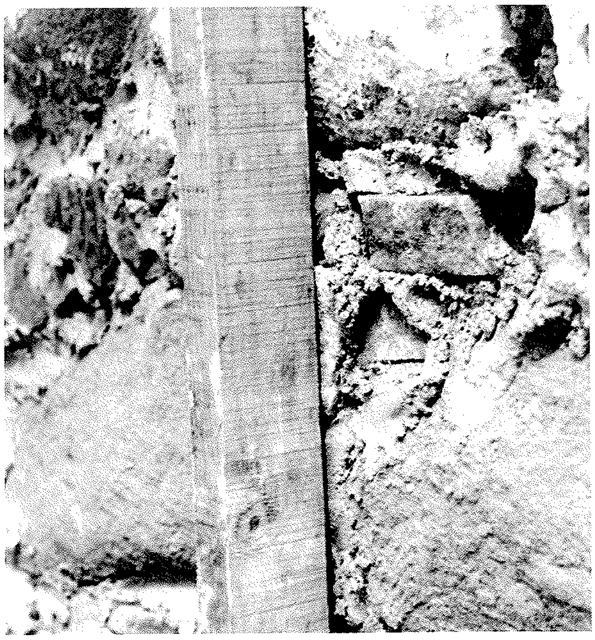


Fig. 67 Checking degree of straightness of wall during building out.

Fig. 68 Placing mortar in joints.

Fig. 69 Placing pinnings into joints.

Fig. 70 Sequence showing placing of pinnings (1-6)

Fig. 71 Working over pinnings.

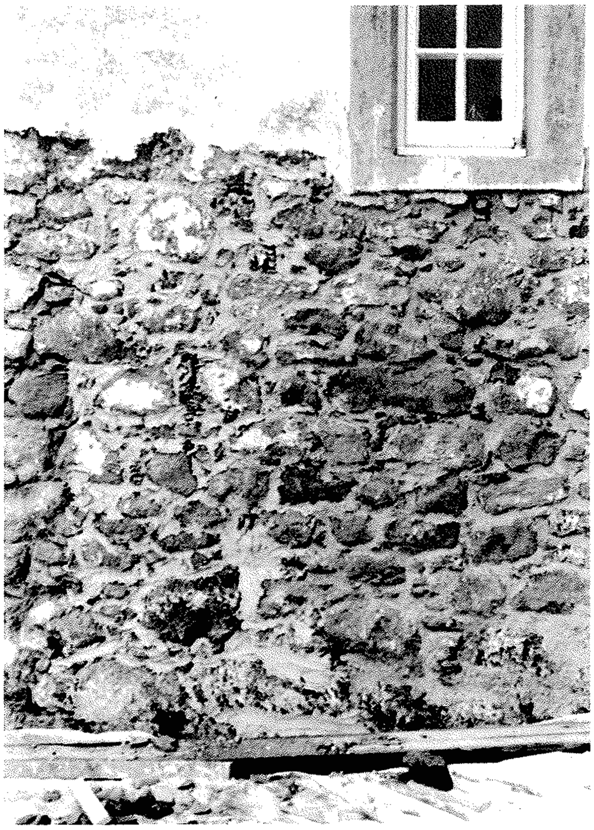


Fig. 72 Final stage of preparation.

Fig. 73 Final stages of building-out.

Fig. 74 Checking level of surface.

Fig. 75 Going over surface with brush after building-out.

B. LIME HARL: APPLICATION

Photographs 76 to 81 illustrate the process of application of lime harl. The extent of pressing back of the harl, if any, will be dependent on the nature of the final finish to be achieved.

Fig. 76 Forehand casting action.

Fig. 77 Working up to a window margin.

Fig. 78 Backhand casting action at low level.

Fig. 79 Working up to existing sound work.

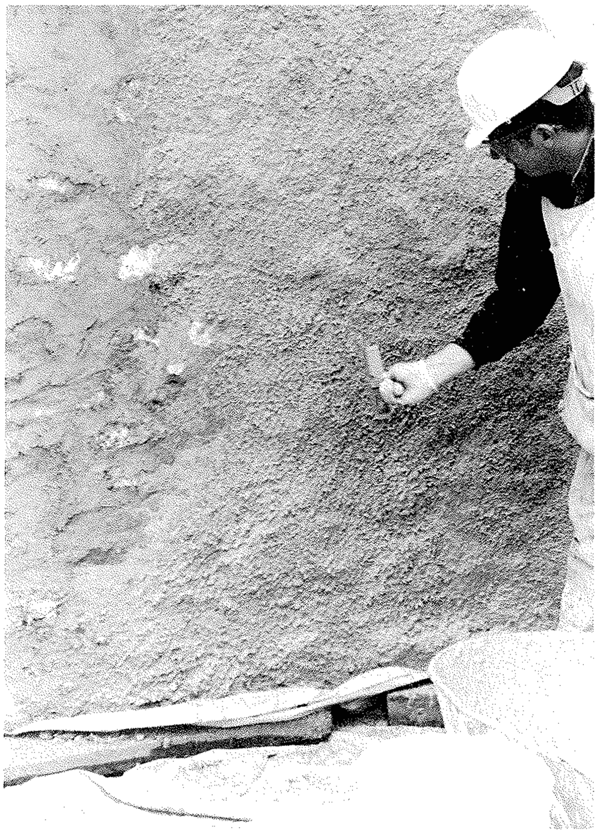


Fig. 80 Backhand casting.

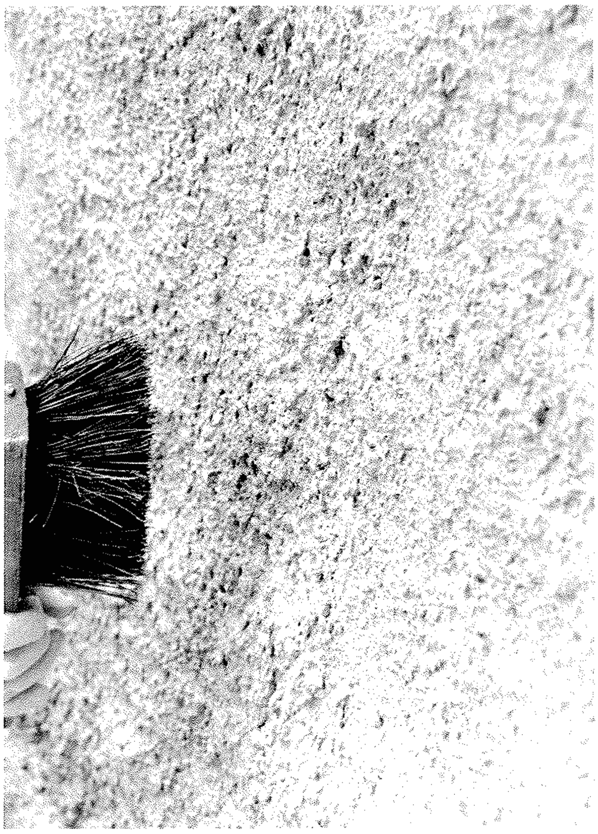


Fig. 81 Going over finished work with a soft brush to push back/remove high spots.

C. FLAT RENDER: APPLICATION

Similar techniques might be used for cast-on application of flat renders, where the second coat can be pressed or lightly worked back with a float and finished, if required, as illustrated in photograph 83. This will give a relatively open textured flat surface which may be lined out, if required, as illustrated in photographs 86 and 87.

Photographs 82 to 86 illustrate dubbing out mortar in readiness for first trowel-applied render coat.

Fig. 82 Pressing back dubbed out repairs.

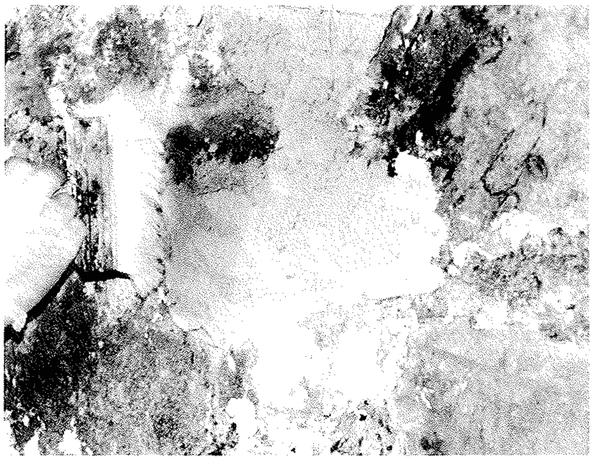


Fig. 83 Pressing back with a damp brush.

Photographs 85 to 89 illustrate application of first and second trowel-applied render coats.

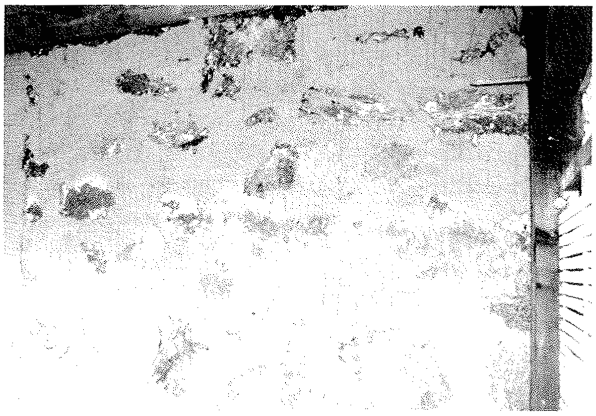


Fig. 84 Dubbing out mortar scratched to provide a key.

Fig. 85 Scratching first coat to receive second coat.

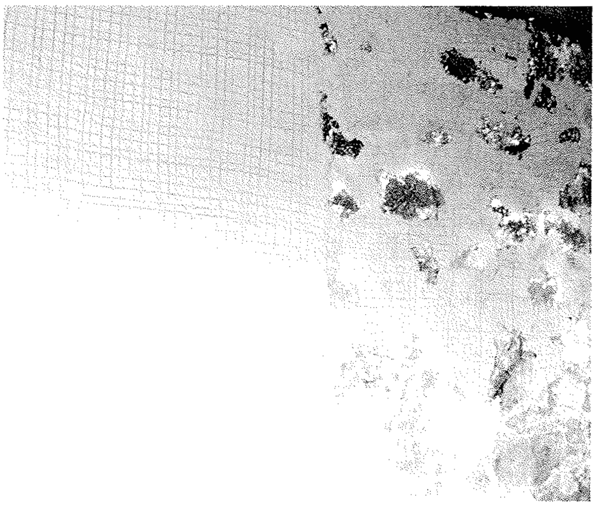


Fig. 86 Fully scratched first coat.

Fig. 87 Damping down to test suction.

Fig. 88 Laying on a second coat. Note the amount of pressure being applied.

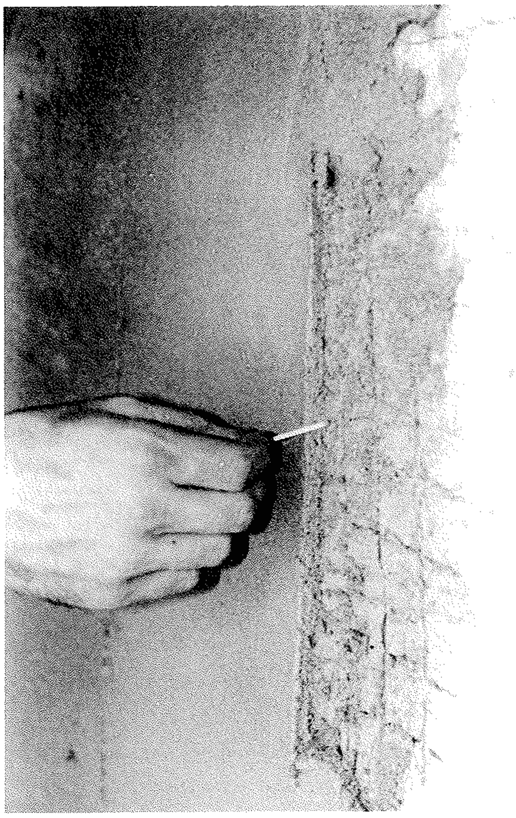


Fig. 89 Showing the thickness of the second coat.

Fig. 90 Scouring (floating) in the second coat.

Photographs 91 to 94 illustrate application of the finishing coat and lining out. The process of lining out to imitate ashlar work should only be undertaken where there is previous evidence for its use.

Fig. 91 Applying the finishing coat.

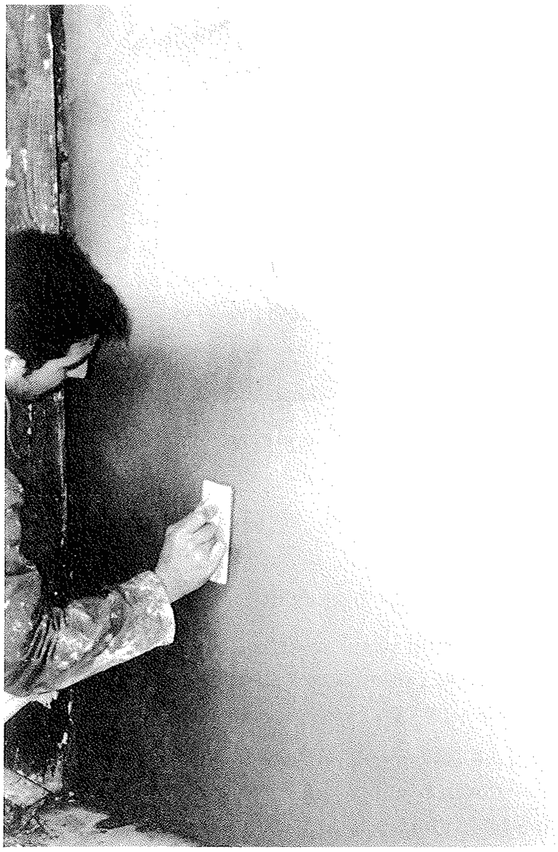


Fig. 92 Floating the finish in small areas.

Fig. 93 Ruling in vertical joint lines. The horizontals were lined first.

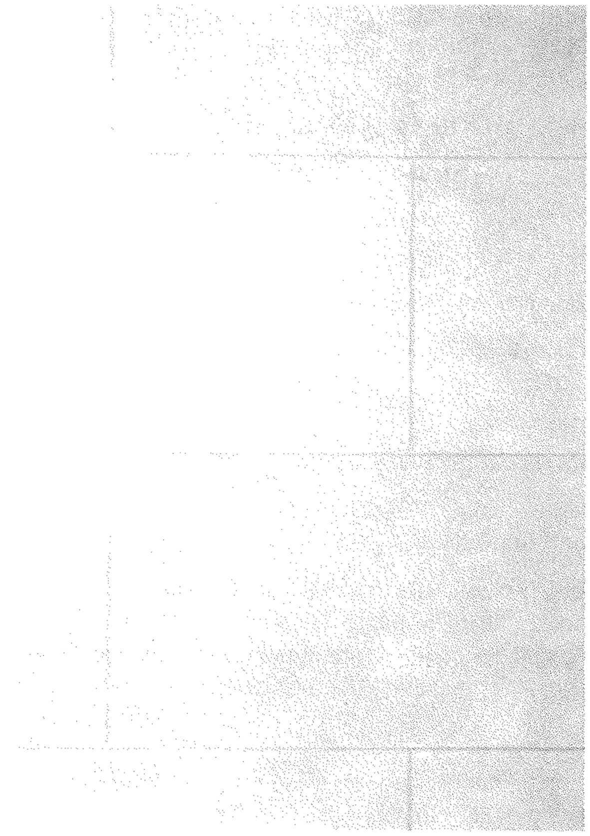


Fig. 94 The completed work.

For weathering and potentially increased life span, the finished surfaces illustrated in these photographs would be finished with a traditional limewash. Harled or rendered surfaces, especially those comprising non-hydraulic mortars, tend to weather more quickly if they are not protected by a well maintained limewash.

All new lime based coatings should be protected from rapid drying and from rain until a sufficient degree of carbonation is achieved. Thereafter the coatings should not be exposed to frost until fully carbonated. These processes are described in the main text at section 3.9.

APPENDIX B
SUMMARY CHECKLIST OF GOOD PRACTICE

B1 SELECT APPROPRIATE MATERIALS.

Investigate any existing lime coatings on the building.

Preserve existing materials wherever possible.

Investigate the characteristics of masonry, local climate and conditions.

Investigate materials available, using local sources where appropriate.

Lime materials should always be weaker than the host masonry.

Do not compromise lime materials by using them in conjunction with modern materials and technologies.

Be aware of other influences or constraints, particularly in urban or marine locations.

Materials that are too strong for the host masonry will trap moisture in the wall leading, potentially, to stone decay and interior damp problems.

Non-hydraulic mortars cannot harden in wet conditions and are not suitable in situations of continuous saturation.

Non-hydraulic mortars that remain saturated will be vulnerable to damage by frost action.

Non-hydraulic mortars in permanently wet situations will be susceptible to leaching of lime.

B2 APPROPRIATE DETAILING.

Protect edges of harls and renders as effectively as possible.

Avoid formation of exposed ledges.

Modify or improve problem situations where possible.

Continuously saturated areas, caused by details catching rain, will be prone to staining, frosting and accelerated decay.

Water splash from adjacent hard surfaces can damage lime coatings, particularly if road salts are present.

B3 PREPARE MATERIALS CORRECTLY.

Lime putty should be well matured.

Hydraulic lime hydrates should be fresh.

Ensure materials are stored in conditions which will prevent drying out (mortar and putty) or dampness (dry hydrates).

Use clean, well graded, sharp sands.

Ensure ratios of lime to aggregate are correct for the types of lime and aggregate.

Ensure any gauging is accurately measured and thoroughly mixed.

Knock-up materials thoroughly.

Do not add extra water to substitute for knocking-up. Where required, extra water should be added after the initial knocking up.

Inadequate mixing and maturing, or the use of excessive water, will result in lack of cohesion within the mortar, resulting in loose and crumbling materials.

Uneven gauging or measuring of lime/aggregate ratios may result in variations of strength in the material.

Inadequately mixed gauging may result in leaching-out of concentrations of free lime.

B4 GOOD WORKING PRACTICES.

Fully prepare walls prior to application of lime coatings.

Remove all dust, debris and vegetation.

Dampen down sufficiently to control suction.

Do not use lime *coatings* to 'dub-out' uneven wall surfaces.

On surfaces without adequate suction, provide a mechanical key (e.g. a splatterdash coat).

Allow saturated masonry to dry out before applying new lime coatings.

Insufficient dampening down of dry porous backgrounds, resulting in excessive suction, will cause shrinkage cracking, loss of bond between coats or with substrate, and a weak and friable mortar.

Apply lime harls and renders in thin even coats.

Excess thickness of material may not fully carbonate and may develop shrinkage cracks.

Leave an open texture to the surface, avoiding excessive working of the material.

Overworking of the material may bring free lime to the surface and cause a skin (laitence) to form. This may lead to loss of bond between coats and to the material being unable to carbonate properly. Excessive overworking will impoverish the lime mix by removing lime in the form of laitence.

Saturated walls will continue to dry out after the lime coating is applied. This may cause continuing dampness in the coating, which may then be vulnerable to frost. Any soluble salts moving into the coating may lead to pitting and spalling of the surface, showing a white 'bloom'. (Lime coatings may be applied, for this purpose, as a poultice to draw salts out of the masonry.)

Lichens and vegetation not fully removed may grow back through the new coating.

B5 APPROPRIATE WORKING ENVIRONMENT AND PROTECTION.

Provide appropriately designed scaffolding for the best working access, from which protection may be hung.

Ensure that roof coverings, rhones and down pipes are functioning before work begins, otherwise make temporary provision for rainwater disposal.

Provide adequate protection over the top lift of new work.

During application and curing provide protection against rain, rapid drying by sun or wind, and frost.

Dampen down the surface on new lime materials, as required, to slow the rate of drying.

Where new lime materials are placed after September or before April, protect from frost for at least three months (or longer if necessary).

Shrinkage cracking or areas of material with an open friable texture will occur in lime coating materials if rapid drying occurs (by sun or strong winds) before proper carbonation.

Rapid drying may also draw lime to the surface, making the materials appear over-white.

Non-hydraulic lime will not carbonate in situations of continuous saturation.

Hydraulic lime mortars may become friable if insufficient water is available for the hydraulic set to take place.

Rain or other continuous saturation may cause lime leaching and staining on neighbouring components, as free lime is mobilised.

Immature or uncarbonated mortars, and non-hydraulic lime materials in continuously wet situations may be damaged by frost action.

APPENDIX C
HEALTH & SAFETY

These notes are intended only as an awareness guide. Full health and safety documentation should be provided for all materials (including lime based materials) and methods to be used in a building contract.

C1 LEGISLATION.

Working practices with lime mortars and harls will generally fall within the scope of the Health & Safety at Work Act, 1974. The Construction (Design & Management) Regulations, 1994 may apply to the design and management of the works.

C2 MATERIALS.

Lime products should be handled with care. As with most other common building materials, slaked lime products can be used without danger provided a few simple precautions are taken.

Limestone and fully carbonated mortars are largely inert. They present some danger to the eyes from dust or particles.

Slaked lime products are a caustic alkali and are irritant or drying to the skin. There is some danger if slaked lime is not fully matured, as the slaking process might still be active. This will be most dangerous to the eyes.

Quicklime is potentially the most hazardous form of lime. It is highly caustic and can cause skin burns. It is extremely dangerous in the eyes. Quicklime should not be specified for use on site unless experienced personnel are available. The use of quicklime requires particular attention to health and safety issues.

C3 POTENTIAL HAZARDS.

C3.1 Skin contact.

Hazards:

Slaked lime materials are drying to the skin and can be an irritant.

Quicklime causes irritation or burning of skin.

Always avoid skin contact with quicklime. Avoid skin contact with other lime materials wherever possible. Especially in warmer weather, shaven parts of the face and neck are liable to irritation.

Personal Protective Equipment:

Wear clothes that provide maximum skin cover.

Wear protective gloves. In wet conditions, or where the hands may come into contact with lime putty or milk of lime, waterproof gloves should be used.

Use barrier cream on the hands, wrists and exposed areas of skin.

C3.2 Eye contact.

Hazards:

Hydrated lime dust in the eyes is extremely painful, and may cause damage.

Quicklime in the eye is particularly dangerous. It can cause severe burns, and can easily cause permanent eye damage.

Personal Protective Equipment:

Use eye protection when slaking quicklime, working with lime based materials overhead, and when applying harling or limewash.

Wear goggles to prevent lime entering the eyes. Wide vision, full goggles with anti-mist properties are preferred.

C3.3 Inhalation.

Hazards:

Inhaling slaked lime dust may cause throat irritation.

Inhaling quicklime dust can cause caustic burns to the mucous membranes.

Personal Protective Equipment:

Wear a dust mask when exposed to lime dust. A dust mask consisting of gauze-covered aseptic cotton wool filter pads, held in a wire frame with a headband, is effective for protecting the mouth and nose.

C3.4 Ingestion.

Hazards:

Slaked lime is likely to cause irritation of the gastro-intestinal tract if swallowed in large doses.

Ingestion of quicklime will cause internal caustic burns.

Keep uncarbonated lime materials away from foodstuffs.

C4 FIRST AID TREATMENT.

C4.1 Skin or eye contact.

Any lime materials in contact with the skin should be washed off immediately with soap and water.

Keep a first aid box to hand when working with lime materials. Cuts and abrasions should be cleaned and covered.

If serious burns are sustained, medical attention should be sought.

Any lime material in the eye should be removed immediately.

Use a cotton wool bud to remove lime particles from the eye.

Irrigate for at least 20 minutes with clean running water or proprietary eyewash. If possible the water should be distilled and as close to the body temperature as possible. (Some people recommend the use of a very dilute sugar solution which, being slightly acidic, counteracts the alkalinity of uncarbonated lime).

Make sure eye irrigation equipment is close to hand when using lime materials.

Medical attention should be sought if quicklime has entered the eye, and irrigation continued until attention is available.

C4.2 Inhalation of lime dust.

Thoroughly irrigate the nose and throat with water, ensuring that the airway remains clear and that aspiration of water is avoided.

Remove the affected person to fresh air, keep them warm and at rest.

Medical attention should be sought.

C4.3 Ingestion of lime.

Do not induce vomiting.

Wash the mouth out with water and ensure copious quantities of water are drunk.

Medical attention should be sought.

C5 FIRE HAZARDS.

Slaked lime products are non-flammable and inhibit combustion. No special fire fighting equipment is required.

Storage of quicklime requires special consideration, due to the heat generated if it comes into contact with water.

APPENDIX D
OUTLINE STRUCTURE FOR SPECIFICATIONS

Each project requires a different solution. It is not appropriate to rely on, or enforce, a standard specification. Because there is limited experience in the building industry of working with traditional materials and methods, it is recommended that the specification should cover production and use of lime based materials in detail. Depending on the nature and extent of the proposed works and their relationship, if any, to a wider project specification, the structure of a specification for external lime coatings may take a variety of forms.

For the simplest situations, perhaps involving repair or reinstatement of external lime coatings, a description of works, setting out standards, materials and techniques may be all that is required. The specification should, nevertheless, include all the necessary information to ensure that the works are priced and executed appropriately. The topics set out below, in the context of more comprehensive project specifications, should provide a checklist of items to be covered.

For more complex projects it will often be necessary to integrate the specification of lime based coatings with a wider job specification based on, for example, the NBS (National Building Specifications) format, *but the actual specifications should be purpose-written for the job in question.* The structure and suggested content of specifications described below mirrors that of many modern specification systems, in particular the widely used NBS format, and the range of information suggested is not unique to lime-based materials - it parallels that which should be provided for any type of material and work practices.

Under the NBS format, specifications for the *production* of lime-based mixes for external coatings such as harling and rendering (and for making good of surfaces prior to application of harl and render) would normally be included in *Worksection Z21 - Mortars, Plasters, Renders and Grouts.* Specifications for *application* of harling and rendering might be included under a *Worksection M21 - External lime based coatings;* and for limewash under a *Worksection M61 - Limewash.* In addition, specifications for making good or 'fairing-out' of eroded or damaged masonry will often be required. For ease of reference it is suggested that these should be included in the relevant M21 and M61 Worksections alongside the specifications for preparation of surfaces and application of finishes, but cross reference from *Worksections F2O, F21* etc, covering various stonemasonry works, might be useful.

It will normally also be necessary to include specific information on design of the scaffold to provide appropriate access and working conditions and ongoing protection for lime-based external works.

As a guide, a specification should include at least the following subjects. Other site-specific information will also be required.

D1 SCAFFOLDING AND GENERAL ACCESS

Specify the design requirements of the scaffold, access and other requirements as they relate specifically to the application of external lime coatings, etc. (It should be made clear which requirements are to be the responsibility of the general contractor or scaffolding subcontractor, and which are the responsibility of the (specialist) subcontractor for the lime based works. If this information is included in the general contract specifications a cross reference and appropriate additional information should also be included in the relevant trade Worksections.)

D2 SPECIFICATIONS FOR MATERIALS AND MORTAR MIXES

Under *Worksection Z21 Mortars, Plasters, Renders and Grouts*, detailed information should be provided on materials and on methods and techniques of production of the various mortar mixes required for making good masonry surfaces and harling, rendering, etc. A specification of constituents and proportions should be provided for each individual mix. This Worksection is likely to include information such as:-

DEFINITIONS (if there is likely to be any doubt about the meaning of terms used in the Z21 Worksection, e.g. where contractors may not be familiar with terms or descriptions of traditional limes and lime based materials).

GENERAL REQUIREMENTS (covering matters of overall relevance to the production of mortars, such as workmanship and particular requirements or constraints).

Standards: -

Specify standards of supervision, skills, experience required for the production of mortars.

Specify quality control procedures including, if required, arrangements for quality control sampling and checking of materials and mixes.

Analysis of existing materials: -

Specify requirements for analysis of existing materials if appropriate, including acceptable specialist laboratories.

D2.1 MATERIALS (covering sources, types and qualities of all materials to be used in the production of lime based mortars)

Purchase of ready made mortars: -

Note acceptability of, and / or requirements for, purchase of pre-mixed materials.

Specify constituent materials, production methods and maturing / storage conditions for pre-mixed materials, as below.

Where appropriate, identify acceptable sources of supply.

Requirements for contractor-made mixes: -

Specify constituent materials, production methods and maturing / storage conditions for contractor-made materials, as below.

Constituent materials for lime based mortar mixes:-

Specify quality and characteristics (and sources where appropriate) of all limes, sands and other aggregates, and other constituent materials for lime based mixes.

Note relevance and application of BS and ENV, or other, standards.

Specify requirements for handling, storage etc of individual materials.

D2.2 WORKS (MORTAR PRODUCTION) (covering the working methods and techniques required to make appropriate mortars)

Methods of mortar production: -

Specify types of machinery, if any, and production methods.

Specify requirements for measuring, batching and mixing the required lime based mortars.

Specify the requirements for storage and maturing of mortars.

Works required to mortars on site: - (or cross refer to other Worksections)

Specify the knocking up processes required on site.

Specify techniques of adding gauging materials on site.

Specify handling and storage requirements on site.

Details of individual mortar specifications: -

Note identification, location and constituents and proportions of each mortar mix.

D3 SPECIFICATIONS FOR WORKING PRACTICE ON SITE

Under the relevant Worksections for application of materials (e.g. *Worksection M21 External lime based coatings*, and *Worksection M61 Limewash*, the following information will be required: -

DEFINITIONS (where there is a need to clarify or establish definitions for the purpose of the contract).

Define what is meant by 'harling', 'rendering', etc. (e.g. a traditional lime based wall covering, applied to the wall by casting by hand) including the number of coats, and type of surface finish etc.

GENERAL REQUIREMENTS (covering matters of overall relevance such as workmanship and particular requirements or constraints).

Access, etc: -

Identify responsibilities of the (specialist) subcontractor and general or scaffolding contractor. (See notes on scaffolding and general access, above.)

Standards: -

Identify the required skills/experience of site supervisory staff.

Note the relevance (or not) of individual British Standards etc.

Note the requirement for a matching standard of workmanship and finish to agreed samples or to surviving original work.

Specify the required skills / experience of tradesmen.

Methods of working: -

Note the need to follow instructions, always allowing for agreed contractor variations, for preparation, application, protection, and curing.

Highlight the differences between lime and cement practice.

Note the requirement to produce mortar in accordance with specified methods.

Timing of the work: -

Specify any requirements for sequence of works etc.

Specify the preferred period of work.

Specify the special requirements that apply to work outside this period.

Protection of work: -

Specify the requirements for general protection of works, protection of adjoining fabric etc, and cross-refer to the requirements for working and curing.

D3.1 MATERIALS (providing information on type, quality, size, source, handling and storage, etc, for all materials to be used in this section of the work)

Specify any requirements for obtaining mortars, whether to be purchased, site mixed etc.

Specify the type of mortar for all applications (Under the NBS format this will normally mean cross reference to specific mortar types defined and specified in *Worksection Z21*), including mixes for making good wall surfaces, and all harling or render coats.

(As an alternative, perhaps where the works do not form part of a wider contract, information on production of mortar mixes could be included within the Worksections covering application of external lime coatings and limewash. In this case it will be necessary to include information on constituent materials, proportions, and methods of production, maturing, etc.)

Specify methods of knocking up and, where required, gauging, of mortars on site before application.

Note the degree of flexibility (if any) to be allowed to the contractor for minor adjustments to suit site conditions.

Specify the need for and type of pinnings or gallets.

D3.2 PREPARATION (describing any preliminary or preparatory actions required before the actual works are undertaken)

Specify any requirements for recording, identifying exact locations of various treatments etc, before and during work, and for recording of actual mixes as used on site.

Specify the extent and methods of removal of vegetation.

Identify the requirements for sample areas of work, to be undertaken in advance of the main works, for approval and quality control, and the location of these samples.

D3.3 WORKS (describing the location and extent of work to be undertaken, and the methods of carrying out the work, actions required, etc)

Clearly describe, with drawings if necessary, specific areas that are to be conserved, repaired, renewed, etc and identify the mortar mixes, finishes, etc to be used in each location.

Preliminary works / making good of surfaces: -

Specify locations and methods of pinning out, making good of surfaces etc, prior to application of the surface coatings.

Specify curing time etc of these works before application of coatings.

Preparation of surfaces: -

Specify preparation of surfaces by brushing / washing down, etc.

Specify measures to control or improve suction and adhesion.

Application of lime based coatings: -

Specify the requirements for handling and knocking up mortar on site.

Specify the methods of preparation, working and application. Cross-refer to requirements for curing.

Specify the requirements at junctions, etc.

Include, or cross-refer to, limewash specification.

Protection and curing: -

Specify the minimum level of protection.

Identify conditions requiring further special protection.

Specify procedures for curing.

Specify the requirements for special measures for out-of-season working.

APPENDIX E
MAINTENANCE CHECKLIST

Most owners or managers of traditional buildings will be aware of the importance of routine and long term maintenance for their building generally. The maintenance of the lime finishes should form an integral part of the regular maintenance routine of the whole building. The main points to be considered are:-

- Ensure the building is properly maintained, particularly with regard to rainwater disposal: -

  Attend to defects promptly.

  Ensure eaves, copes and projections are shedding rainwater effectively.

  Fix leaks in rhones (gutters) and downpipes promptly.

  Ensure water drains away from the base of walls.

  Maintain good ventilation of lime coatings at base level by keeping plants away from the walls.

- Make good any minor defects as soon as possible: -

  Repair any minor loss of harling or render and erosion of limewash on an ongoing basis. (This can be regarded as routine 'housekeeping' maintenance in the same category as clearing out rhones, re-fixing loose slates, etc.) It will normally be possible to keep limewash in a re-sealing container for this purpose, which can be simply brushed on to minor defects as a first aid repair.

- Undertake periodic re-limewashing to maintain the lime harl or render: -

  Plan for a second application of limewash if possible during the early years after harling.

  Follow this by a number of re-applications to build up the layers over a number of years.

  Thereafter, undertake re-limewashing on a 10 to 15 year cycle, or as required.

- Do not impose inappropriate details or materials on lime coatings: -

  Avoid patching coatings with materials that are denser than the existing.

  Do not apply modern, relatively impermeable, paint systems or sealants to lime coatings.

  Do not introduce details which change the way water is handled, without due consideration.

  Normal weather staining or lichen growth may occur, especially at points of concentrated water run off, or at permanently shaded and poorly ventilated areas. This can be seen on any similar traditional building and is not directly related to the use of lime finishes.

- Do not expect a bland, uniform finish. Expect a certain degree of colour variation as the coating becomes wet and then dries.

APPENDIX F
GLOSSARY OF TERMS

Aggregate: any material which, when used in combination with a binder, forms a mortar. This can include sand, crushed rock, brick dust, or any other appropriate filler.

Air limes: non-hydraulic limes, limes that set through carbonation, rather than through chemical reaction with water. So called because they set in air.

Aluminates: compounds of aluminium and oxygen.

Argillaceous: containing clay substances. May be used in connection with some types of sandstone.

Ashlar: stones with hewn or polished surfaces built with tight joints, to be seen as face work.

Binder: material that binds together the aggregate particles in a mortar, e.g. the lime, gypsum, clay, cement, etc.

Burnished limewash: a necessary part of the application of limewash, which involves vigorous agitation of the surface of the material after brushing on, and during the setting process.

Calcium carbonate: chemical state of the raw limestone material, and of fully set lime mortars.

Capillary action: a phenomenon arising from the surface tension of a liquid, whereby it is drawn up through thin tubes or pores within the structure of a host material.

Carbonation: the process by which fresh lime mortar re-absorbs carbon dioxide in moist conditions and reverts to calcium carbonate. As a result of this process lime mortar becomes relatively harder, more stable and less soluble.

Casein: a protein in milk and its products. In some situations it can improve the durability of limewash.

Casting: the throwing on of a wet lime harl, usually done by hand with a trowel.

Cement: a quick-setting binder for making mortars. Commonly available as Portland cement. Historically, natural cements were also available, produced from naturally occurring combinations of limestone and clay.

Cementitious: a description of the setting property of a mortar, by the chemical action of formation of tri-calcium silicates and aluminates, as in cement.

Cherry cocks: small stones placed into the surface of joints between stones in a wall, often in a formal pattern.

Coarse stuff: a mixture of lime and coarse sand or other aggregate for use as lime mortar.

Concrete sand: a marketed commodity, of siliceous aggregate comprising a range of particle sizes including small pebbles or grit, suitable for use in making concrete. Also generally suitable for use in lime mortars, harling, etc.

Copperas: sulphate of iron, used as a colouring agent to produce orange shades in limewash.

Coursed stonework: built masonry where each layer has a clearly defined horizontal alignment of uniform, or near uniform, height. Course height is often dictated by the size of the largest stones used in the construction.

Dash coat: the final coat of a lime harl, thrown or cast on from a trowel.

Debris netting: a form of protective barrier used to enclose a safe working area. Often an open-woven polypropylene material is used.

Dry dash: a finish not normally recommended for lime based coatings. The final surface comprises a dry aggregate cast against a wet mortar background.

Dry hydrate: hydrated lime in which quicklime has been slaked with just enough water to form calcium hydroxide in the form of a dry powder.

Dubbing out: the act of filling out and levelling uneven surfaces in a wall, in preparation for render or harling. When working with lime mortars pinnings are placed into the mortar to bring forward eroded or missing surfaces to create a suitably level (but not necessarily entirely flush) wall to receive a harl or render finish. Also known as fairing out.

Eminently hydraulic lime: lime prepared from limestone containing a high proportion of reactive silica or silica/alumina, giving a relatively rapid set and increased hardness.(See hydraulic lime).

Fairing out: see dubbing out.

Fat lime: non-hydraulic lime, consisting almost entirely of calcium hydroxide, plus water. Also known as 'air lime'.

Fatten up: the slow absorption of water into an uncarbonated lime material, making it more plastic.

Feathering out: to gradually reduce the thickness of an applied lime coating as it reaches the edge of a panel or feature. This allows the different planes of a surface to be visually integrated.

Feebly hydraulic lime: a hydraulic lime which has the lowest reactive silica/alumina mineral content, and therefore has a weak chemical set in conjunction with the process of carbonation.

Float: a tool for laying-on and finishing mortar or render coatings.

Friable material: a material that can be easily crumbled. May describe masonry or mortar materials.

Gallets: small pieces of stone, tile or other suitable permeable material which might be pressed into lime mortar on the face of walls to bring forward eroded surfaces as part of the process of fairing out.

Gauging: literally, the measuring of materials in combination.

Green: the transitory state of a mortar in the process of drying out. The mortar will have developed a little mechanical strength, but full carbonation or hydraulic set will not have been achieved.

Grouting: filling joints, crevices or voids in walls, which are too small or inaccessible to be filled using mortar of normal consistency, using a very fluid binding material.

Harling: a thrown, or cast on, finish of lime and aggregate.

HTI: a finely ground powder with pozzolanic properties, derived from high-temperature ceramic insulation material.

Hydrated lime: see dry hydrate.

Hydraulic lime: lime prepared from limestone containing reactive silica or silica/alumina, often, but not necessarily, in the form of clay minerals. These give the mortar a chemical set that is quicker and harder than the carbonation of pure limes, and an ability to set in wet conditions. Limes can be feebly, moderately or eminently hydraulic. Hydraulic limes cannot normally be stored as putty for any length of time because the chemical set will cause them to harden, and they are therefore stored as dry hydrate. Also known as 'water lime'.

Keyed: description of a surface which has been prepared for the application of a further mortar finish by scoring to provide a physical attachment between layers.

Knocking-up: the re-working of a mortar mix to re-gain plasticity before use.

Laitence: a surface skin that develops on over-worked mortar surfaces, drawing fine material to the surface and reducing permeability.

Larry: a long-handled hoe used to mix lime putty and coarse stuff.

Laying on: the act of application of a trowelled render coat. Commonly used to describe the first coat of a two-coat finish.

Lime (hydraulic): See hydraulic lime.

Lime (non-hydraulic): See non-hydraulic lime.

Lime putty: hydrated lime which has been slaked from quicklime using sufficient water to form a thick liquid and subsequently settled out to a putty during storage.

Lime-water: a saturated solution of calcium hydroxide in water. Left when lime putty settles out of slaked lime. Used for consolidation of friable surfaces.

Limewash: a suspension of lime (putty) in water, used as a form of paint for surface protection or decoration.

Moderately hydraulic lime: see hydraulic lime for definition of different degrees of hydraulicity.

Mortar: any material which can be worked or placed in a plastic state, becomes hard when in place, and which can be used for bedding, jointing or finishing the component parts of a wall.

Movement joints: a function adopted in modern building practice, where joints are created between inflexible sections of wall or wall finishes. They permit thermal movement of the wall to occur without cracking brittle finishes.

Milk of lime: a free-flowing suspension of hydrated lime (lime putty) in water, in such proportion as to resemble milk.

Non-hydraulic lime: a pure lime, consisting almost entirely of calcium hydroxide without reactive silica or silica/alumina. Non-hydraulic lime mortars harden only by slow drying and carbonation, and cannot set in wet conditions. Also known as fat lime or 'air lime'.

Perpend: a vertical joint in masonry walling.

PFA: pulverised fuel ash. A waste product from power stations, used as a pozzolan in modern cementitious mortars and grouts.

Pigment: colouring material, used, for example, in limewash.

Pinning stones: small stones or shells, etc placed in joints to stabilise masonry and reduce the volume of mortar required. Also used in conjunction with mortar in re-pointing etc.

Plaster: any material used in a plastic state to form a durable coating to the surfaces of walls, ceilings, etc. May be based on limes, gypsum, cements or clays, usually with a sand filler.

Plasticity: a description of the ease of spreading and cohesiveness of a mortar mix.

Portland cement: the common form of cement made by grinding clinker formed by firing clay and limestone at high temperatures.

Pozzolans: materials containing fine particles of reactive silica and alumina, and sometimes iron oxides, which will react with calcium hydroxide and water to produce a chemical set in mortar, similar to the set achieved by hydraulic limes.

Putty: see lime putty.

Quicklime: calcium oxide. A highly caustic material produced by burning limestone. Quicklime is slaked with water to produce lime for building works.

Render: an external plaster system.

Roughcast: another term to describe a thrown harl finish. (Also wet-dash). The terms are more commonly used in English practice.

Rubble: Masonry using irregular and variable sized pieces of stone to create a strong construction. Walls vary in appearance depending on the builder and the nature of the building stone. Contrary to popular belief the wall is usually built in courses, not random.

Salt efflorescence: the crystallisation from solution of soluble salts from within a structure. Normally associated with the drying out of wet walls.

Sanded limewash: limewash to which fine sand has been added before application, to assist in durability of the wash in exposed locations.

Scouring: the tightening-in of a render or plaster surface by working it in a circular motion with a cross-grained float.

Slaking: the controlled process of combining quicklime with water to form slaked lime, as lime putty or dry hydrate.

Slurry: a thick, but fluid, mixture.

Spalling: the degradation of masonry or lime materials through loss of surface parts or layers.

Splatterdash: a thin thrown application of mortar, partially covering the surfaces of stones, usually to provide a key on dense surfaces.

Stucco: from the Italian word for plaster, adopted to describe high quality external render, often in imitation of masonry.

Stugging: the action of dressing the surface of a stone with indentations to provide a key to which cement render will adhere.

Suction: the characteristic by which a wet bond is created between lime mortars, (or other mortars) and porous masonry surfaces.

Tallow: animal fat, used in limewash to introduce some additional water resistance.

Tampers: tools of various shapes for pushing mortar into joints.

Water limes: hydraulic limes, so called because they will set in wet locations.

Wet-dash: another name for roughcast or harling. A thrown wet mortar coating usually containing coarse aggregate. Not a traditional Scottish term. Often applied to modern cement based finishes.

Whin: traditional but informal name for hard dark grey rocks (usually basalt or andesites).

APPENDIX G
BIBLIOGRAPHY

Ashurst, J and Ashurst, N, 1988, Practical Building Conservation, Volume 3. *Mortars, Plasters and Renders*. English Heritage Technical Handbook. Gower Technical Press, Aldershot.

Ashurst, J, 1983, *Mortars, Plasters and Renders in Conservation*. Ecclesiastical Architects' and Surveyors' Association (EASA), London.

BRE, 1976, Digest 410: *External Rendered Finishes*. HMSO, Watford.

Boynton, RS, 1980, *Chemistry and Technology of Lime and Limestone*. New York. 2nd edition.

British Standards Institution:-

BS EN 459-1: 1999, Building lime. Part 1 *Definitions, specifications and conformity criteria.*

BS EN 459-2: 1999, Building lime. Part 2 : *Test methods.* (Final draft)

BS EN 459-3: 1999, Building lime. Part 3 : *Conformity evaluation.* (Final draft)

(BS 890: 1972 is due to be withdrawn when BS EN 459 is adopted).

BS 882: 1992, *Aggregates from natural sources for concrete.*

BS 1199/1200: 1976 rev 1986, *Building sands from natural sources.*

BS 6262: 1991, *Code of practice for external renderings.*

BS 7913: 1998, *Guide to the principles of the conservation of historic buildings.*

BS 8000, Part 10, *Code of practice for plastering and rendering.*

Burnell, GR, 1867, *Rudimentary Treatise on Limes, Cements, Mortars, Concretes, Mastics, Plastering etc.* Sixth edition, Virtue & Co., London.

Cowper, AD, 1927, *Lime and Lime Mortars.* Department of Scientific and Industrial Research, Building Research Special Report No. 9, HMSO, London.

Department of the Environment, 1975, *Sands and Plasters, Mortars and Renderings.* Advisory Leaflet 15, HMSO, Birmingham.

Fidler, J, 1992, *A good rendering*, Traditional Homes, March 1992.

Gibbons, P, 2001, Scottish Lime Centre Trust, *Preparation and Use of Lime Mortars,* Technical Advice Note 1, Historic Scotland, Edinburgh, Second edition.

Holmes, S and Wingate, M, 1997, *Building with Lime,* Intermediate Technology Publications, London.

Hughes, P, 1986, *The Need for Old Buildings to Breathe*, SPAB Information Sheet 4, The Society for the Protection of Ancient Buildings, London.

Induni, B & L *Using Lime,* (leaflet available from SPAB).

Johnston, D, 1994, *A Guide to Traditional Mortar.* Masons Mortar, Edinburgh, 1994.

Leslie, AB and Gibbons, P, 1999, Scottish Lime Centre Trust, *Scottish Aggregates for Building Conservation,* Technical Advice Note 9, Historic Scotland, Edinburgh.

Knight, J (Ed), 1995, *The Repair of Historic Buildings in Scotland,* Historic Scotland, Edinburgh.

Louden, 1853, *Encyclopaedia of Cottage and Farm Architecture*, London.

Meek, T, 1996, *Case Studies of Traditional Lime Harling:* Discussion Document. Historic Scotland, Edinburgh.

Miller, WS, 1998, *Plastering Plain and Decorative.* Donhead.

Renton, KH and Lee, HN, 1989, *Lime Mortars and Plasters in Building*. Building Technology and Management, April, May, 1989.

Schofield, J, 1994, *Basic Limewash*. SPAB Information Sheet 1, The Society for the Protection of Ancient Buildings, London, 1985, reprinted 1994.

Schofield, J, 1995, *Lime in Building*, Black Dog Press, Crediton, second edition.

Simpson & Brown, Architects, 1994, *Conservation of Plasterwork,* Technical Advice Note 2, Historic Scotland, Edinburgh.

Wingate, M, 1990, *An Introduction to Building Limes.* SPAB Information Sheet 9, The Society for the Protection of Ancient Buildings, London.

Young, R, 1991, *Cement Scorned, Report on External Lime Rendering to No. 33 Gloucester Street, Cirencester.* SPAB News, Vol. 12 No. 1, London.

APPENDIX H
USEFUL ADDRESSES
as at November 2001

Specialist services and materials are currently available in Scotland as noted below. Similar services and materials are also available from a range of sources in England. This information is provided in good faith but the inclusion of any particular firm, individual or product does not imply endorsement by Historic Scotland.

Advice on conservators, craftsmen, conservation contractors and architects: -

The Scottish Conservation Bureau,
Longmore House, Salisbury Place,
Edinburgh EH9 1SH.

Telephone 0131 668 8668

Practical hands-on training and specialist advice on lime based materials: -

Charlestown Workshops,
The Scottish Lime Centre Trust, Rocks Road,
Charlestown, Fife KY11 3EN.

Telephone 01383 872722

Other one-off short courses are provided by various individuals and organisations from time to time.

Traditional lime based materials, including associated specialist materials: -

Cumming & Co, 8 Whitefriars Street, Perth PH1 1PP. Telephone 01738 567899.
(Lime mortar, limewash, brick dust and marble dust)

Leonard Grandison and Son, Innerleithen Road, Peebles EH45 8BA. Telephone 01721 720212.
(Lime putty and lime plaster)

Rebecca Little, Monimail Tower, Monimail, Cupar, Fife KY15 7RJ. Telephone 07968 494063

Masons Mortar, 77 Salamander Street, Leith, Edinburgh EH6 7JZ. Telephone 0131 555 0503.
(Lime mortars and plasters, lime putty, hydraulic limes, limewash, aggregates and sands, crushed brick and soft-fired brick dust, hair, pigment and other specialist products)

Tim Meek Associates, 65 Gordons Lane, Cromarty, Ross-shire IV11 8XN. Telephone 01381 600510

The Plaster Restoration Company, 1 Beresford Terrace, Edinburgh EH5 3HR. Telephone 0131 552 5363

Sources and suppliers of natural hydraulic limes: -

UK-produced materials

Product name	***hl2* Blue Lias Hydraulic Lime**
ENV class	NHL3.5
Producer	Hydraulic Lias Limes Limited, Tout Quarry, Charlton Adam, Somerton, Somerset TA11 7AN.
Supplier	Available to order from the producer Telephone 01458 223179

French-produced materials

Product name	**St Astier NHL2, NHL3.5, NHL5**
ENV class	NHL2 NHL3.5 NHL5
Producer	UCDC Chaux et Enduits de Saint Astier
Importer	Setra Marketing Ltd
Supplier	Masons Mortar, 77 Salamander Street, Leith, Edinburgh EH6 7JZ. Telephone 0131 555 0503

Product name	**Castle Natural Hydraulic Lime**
ENV class	NHL3.5
Producer	SOCLI, Izaourt, in SW France
Importer	Castle Cement Ltd, Park Square, 3160 Solihull Parkway, Birmingham B37 7YN.
Supplier	Castle Cement, contact Paul Livesey Telephone 01200 422401

Italian-produced materials

Product name	**Unilit Natural Hydraulic Lime**
ENV class	NHL3.5 NHL5
Producer	Tassullo
Importer	Telling Lime Products, Primrose Ave, Fordhouses, Wolverhampton WV10 8AW.
Supplier	Telling Lime Products, contact Jeff Parmley Telephone 01902 789777

Swiss-produced materials

Product name	**JuraKalk**
ENV class	NHL5 (at stronger end of the NHL5 class)
Producer	Jura Ciment Fabriken, CH-5103 Wildegg, Switzerland.
Supplier	Masons Mortar, as above

Other suppliers may be marketing hydraulic limes with a classification of HL, rather than NHL, which may be suitable in some circumstances, but which are not natural hydraulic limes under the definition of ENV 459.

Mortar mixers: -

Roll pan mixers

Liner Manufacturing Ltd, Monckton Road Industrial Estate, Wakefield WF2 7AL. Telephone 01924 290231

Masons Mortar, 77 Salamander Street, Leith, Edinburgh EH6 7JZ. Telephone 0131 555 0503

Paddle mixers

Linco Sales Ltd, Crews Hole Road, St George, Bristol BS5 8AY. Telephone 0117 955 520.

RDS Supplies Ltd, 20 Spring Road Industrial Estate, Lanesfield Drive, Wolverhampton WV4 6UB. Telephone 01902 353252

Specialist analysis of original materials: -

Mortar characterisation, specialist thin section analysis and simple chemical analysis

The Scottish Lime Centre Trust, The Schoolhouse, Rocks Road, Charlestown, Fife KY11 3EN.
Telephone 01383 872722

Chemical and X-ray analysis

Construction Materials Consultants Ltd, Wallace House, Whitehouse Road, Stirling FK7 7TA.
Telephone 01786 434708

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