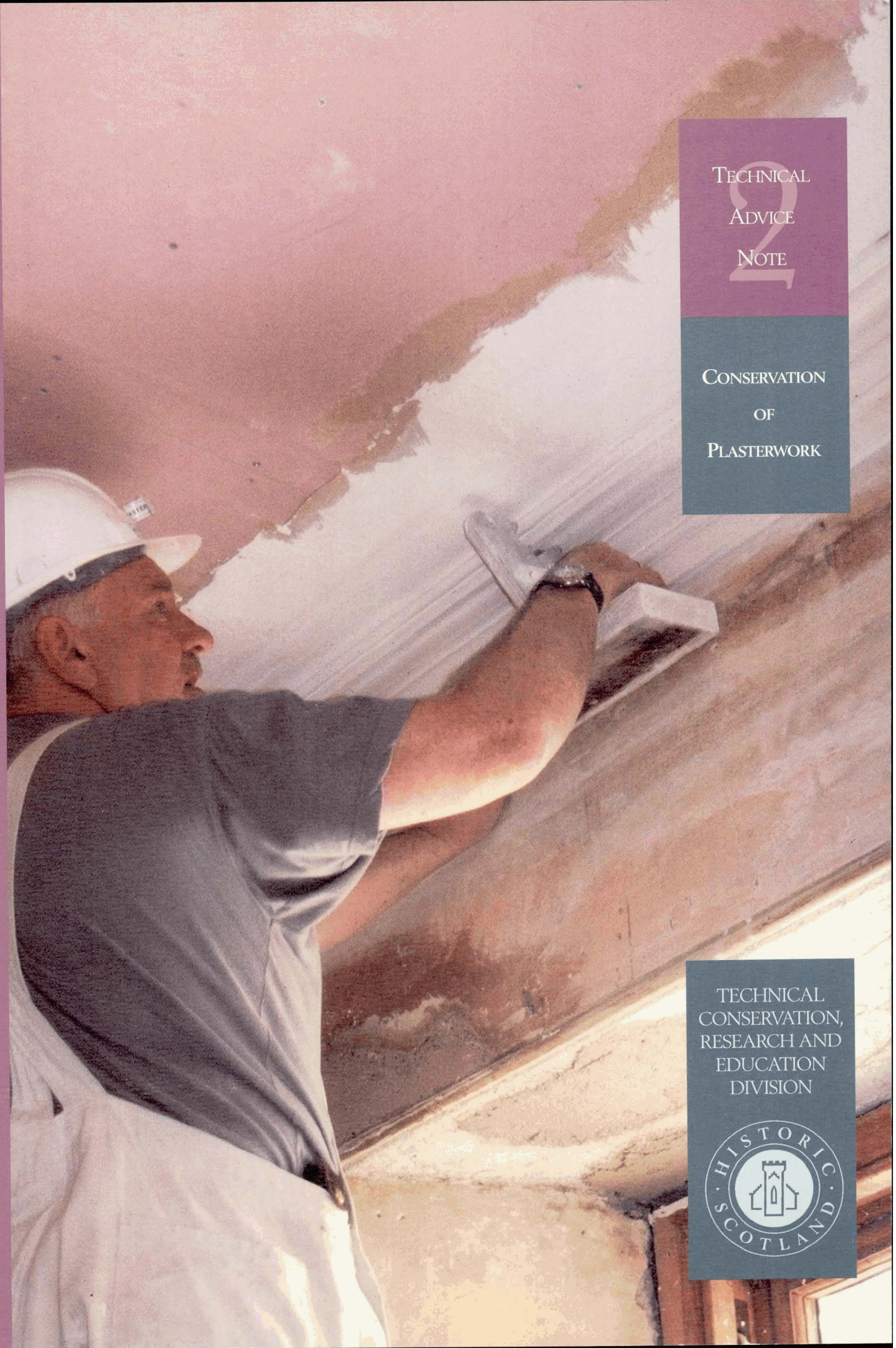
TAN 2

CONSERVATION OF PLASTERWORK



TECHNICAL ADVICE NOTE 2

CONSERVATION OF PLASTERWORK

TECHNICAL CONSERVATION, RESEARCH AND EDUCATION DIVISION

HISTORIC SCOTLAND

HISTORIC SCOTLAND TECHNICAL ADVICE NOTES

1 Preparation and use of Lime Mortars (revised 1995)

2 Conservation of Plasterwork (1994)

3 Performance Standards for Timber Sash and Case Windows (1994)

4 Thatch & Thatching Techniques (1996)
A guide to conserving Scottish thatching traditions

5 The Hebridean Blackhouse (1996)
A guide to materials, construction and maintenance

6 Earth Structures and Construction in Scotland (1996)
A guide to the Recognition and Conservation of Earth Technology in Scottish Buildings

7 Access to the Built Heritage (1996)
Advice on the provision of access for people with disabilities to historic sites open to the public

8 Historic Scotland Guide to International Conservation Charters (1997)

9 Stonecleaning of Granite Buildings (1997)

10 Biological Growths on Sandstone Buildings (1997)
Control and Treatment

11 Fire Protection Measures in Scottish Historic Buildings (1997)

12 Quarries of Scotland (1997)
An illustrated guide to Scottish geology and stone working methods based on the British Geological Survey Photographic Archive of selected building stone quarries

13 The Archaeology of Scottish Thatch (1998)

14 The Installation of Sprinkler Systems in Historic Buildings (1998)

15 Lime Harling and Rendering (2000)

16 Burrowing Animals and Archaeology (1999)

17 Bracken and Archaeology (1999)

18 The Treatment of Graffiti on Historic Surfaces (1999)

19 Scottish Aggregates for Building Conservation (1999)

20 Corrosion in Masonry Clad Early 20th Century Steel Framed Buildings (2000)

21 Scottish Slate Quarries (2000)

22 Fire Risk Management in Heritage Buildings (2001)

23 Non-Destructive Investigation of Standing Structures (2001)

GUIDES FOR PRACTITIONERS

Stone Cleaning – A Guide for Practitioners (1994)
Timber Decay in Buildings – The Conservation Approach to Treatment (1999)
1 Rural Buildings of the Lothians: Conservation and Conversion (1999)
2 Conservation of Historic Graveyards (2001)

Available from:

Historic Scotland
Technical Conservation, Research and Education Division
Scottish Conservation Bureau
Longmore House
Salisbury Place
EDINBURGH
EH9 1SH
Tel 0131 668 8668
Fax 0131 668 8669
email hs.conservation.bureau@scotland.gov.uk

TECHNICAL ADVICE NOTE

CONSERVATION OF PLASTERWORK

by
Simpson & Brown Architects

REVISED EDITION 2002
by
The Scottish Lime Centre

Published by
Historic Scotland

ISBN 1 903570 41 7

Edinburgh 2002

Commissioned by

TECHNICAL CONSERVATION, RESEARCH AND EDUCATION DIVISION

HISTORIC SCOTLAND

This document was prepared and researched by Una Lee and Sonya Larsen, with advice from James Simpson and was edited by Mandy Ketchin, all of Simpson & Brown Architects. The project was co-ordinated by Pat Gibbons for Historic Scotland.

This edition revised and reprinted 2002. Additional text prepared by Pat Gibbons, Scottish Lime Centre.

ACKNOWLEDGEMENTS

The authors would like to thank Paul Drury of the Conservation Practice, who contributed parts of the text and commented on the rest, and also Peter Burman, Sir Bernard Feilden, Leonard Grandison, Peter Hood, Richard Ireland, Tim Meek, Jeff Orton, Tim Radcliffe, Dick Reid, Jane Schofield, Rory Young and others, without whose experience and understanding of the subject, enthusiasm and generosity, this text could not have been produced.

Cover illustration: running a cornice. Photograph courtesy of Alex Hyland.

CONTENTS

LIST OF ILLUSTRATIONS

Plates

Figures

Tables

1 INTRODUCTION

At least since the arrival of the Romans, it has been common for rough stone buildings in Scotland to be finished with clay or lime plaster, inside and out. While external plaster was often dressed with roughcast or harl and coated with natural or pigmented limewash, it was in more formal architecture sometimes finished smooth and 'lined out', and internal plaster was always floated to a more or less smooth finish. This was a natural field for the application of colour or painted decoration, which was sometimes also carried over the exposed beams and boards of the floor and roof structures.

The lining of rooms in the sixteenth and seventeenth centuries, the consequence both of fashion and of rising standards of privacy and comfort, resulted in the concealment of open floors and roofs by plaster ceilings and cornices and often, paradoxically, in the disappearance of plastered walls behind oak wainscot and painted panelling of Baltic pine.

1. Lime plaster on the hard at Collairnie Castle Fife, probably late sixteenth century

During the seventeenth century panelling gradually gave way to lath and plaster wall linings and, in the grandest houses, modelled Palladian and Rococo stucco work. The beginnings of mass-produced ornament came in the second half of the century, with the marketing of standard ceiling enrichments in plaster of Paris and papier maché, and the pressing of 'compo' decorations in boxwood moulds. The nineteenth century saw the rapid development of ornamental plaster technology, mainly based on the casting of gypsum plaster in flexible moulds which permitted undercutting. This culminated (for instance in work of Robert Lorimer at the turn of this century) in the introduction of modern fibrous plaster techniques, in which large sections of ornamental work were cast with timber and scrim reinforcement and then screwed into position.

While fibrous plaster methods have continued to be used for ornamental work right up to the present day, the twentieth century has seen the introduction for plain work of a wide variety of proprietary plasters, designed to save labour, time and money, and a trend towards 'dry lining', resulting in the virtual elimination of the plastering trade altogether. In the process, the traditional techniques associated with lime plaster, stucco and clay have been largely forgotten and it has become common for decayed or damaged plaster of all ages and types to be repaired using inappropriate materials and methods and for ornamental work of all sorts to be 'restored' by fibrous plaster techniques, the surviving original fabric being destroyed and reproduced in the process.

The value of historic plasterwork depends not only on its design, but also - as with a picture or a piece of furniture - on the authenticity of its fabric and the qualities which ageing has introduced. In an architectural context, the reproduction of plasterwork which is important to the overall design, but missing, may well be justified. But good conservation practice requires that, wherever possible, surviving original work should be retained and repaired and, where necessary and appropriate, restored.

This Technical Advice Note contains an account of the types of plasterwork which may be encountered; guidance on how to inspect plasterwork, to assess it, to diagnose defects and to devise a conservation strategy; and advice on repair and restoration methods and their specification. It does not purport to be a handbook for the trade, for which a number of practical references are given in the bibliography. Matters of style and design are also beyond its scope. Current advice on architects, craftsmen, conservators, and sources of materials may be obtained from the Historic Scotland Conservation Bureau.

Authors' note:

In the preparation of this paper we have consulted widely with architects, conservators plasterers and other specialists working with historic buildings. We have tried to take all views into account but have not necessarily committed them all to print. There has not always been full agreement between consultants - most notably on the extent to which lime plasters may traditionally have been gauged with gypsum. There is still much to be learned from documentary and archaeological evidence and from practical experience. We welcome any further comment and where appropriate we will amend any future edition accordingly.

All dimensions are given in metric units with their imperial equivalents - the common thickness of a plaster coat, for example, is about 9mm, which is roughly $^{3}/_{8}$in or the width of a little finger.

2. TYPES OF PLASTER AND PLASTERWORK

2.01 Types of plaster

Clay plasters

The simplest and most primitive of plasters are based on clay, sand and dung, reinforced with chopped straw or other fibrous material. Such plasters were used in truly vernacular buildings on stone walls and wattle partitions throughout Scotland, but they were also used in more formal buildings, for example in estate architecture as late as the 1850s. They were often finished with limewash and they sometimes formed the backing for contemporary or later finishing coats of lime plaster. They have been superseded by more durable and maintainable finishes, but where they survive they are always of historic and archaeological interest. Clay plasters are beyond the scope of this Technical Advice Note but will be covered in a future document dealing with vernacular building techniques.

2. Clay plaster on the hard, from a group of four weavers' cottages known as Jericho, on the Angus and Glamis Estates, built by Firpark of Brigton, 1771-76

Lime plasters

For artisan and sophisticated buildings of all sorts, for hundreds of years before the present century, lime was an essential component of mortars and plasters. Internal plaster, external plaster, roughcast and mortar for building and pointing were fundamentally the same material, differing only in the size of aggregate used and the presence or absence of reinforcement such as hair.

Lime is made by the burning or 'calcining' of limestone (calcium carbonate, $CaCO_3$) in a kiln to produce 'quicklime' (calcium oxide, CaO) which is then 'slaked' with water to produce 'lime putty' (calcium hydroxide, $Ca(OH)_2$). The putty is then sieved to remove any unslaked lumps or extraneous material and run into a pit or a tank to mature. For plastering, the mature lime putty may be mixed with sand to produce 'coarse stuff' or 'fine stuff', or it may be used on its own or diluted to produce limewash. The hardening of each coat of lime plaster relies on the lime setting through carbonation, that is the combination with atmospheric carbon dioxide in the presence of water to form calcium carbonate. This effectively restores the lime plaster to its original limestone state (i.e. chemically identical although physically usually softer); this chemical process continues for many years even within the finished plaster.

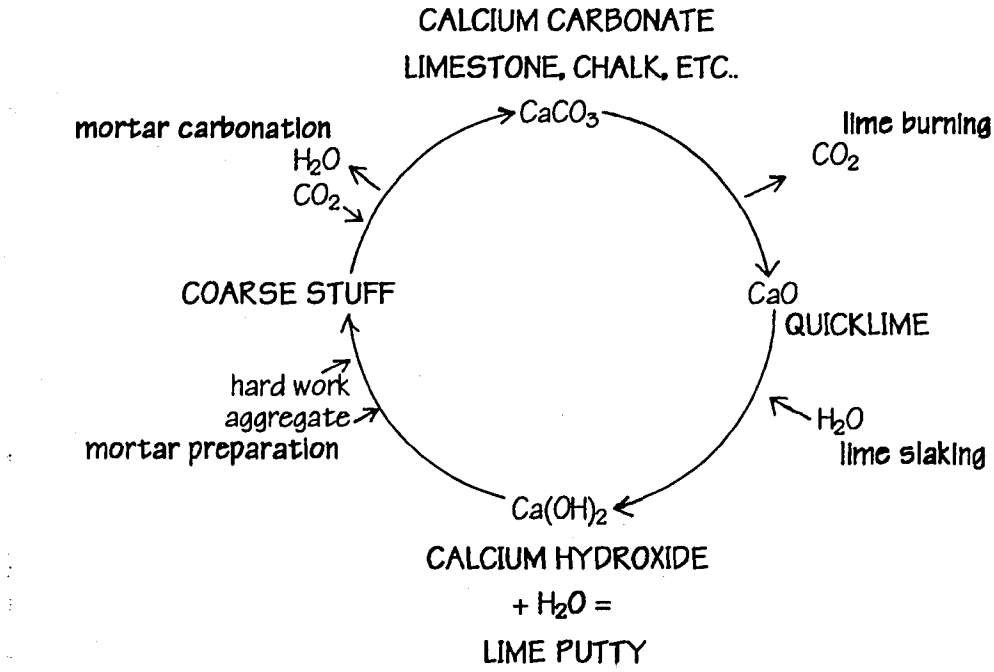


Fig.1 The lime cycle

Lime plaster, reinforced with hair, may be applied direct to stone or brickwork, to wattle, scratched clay or hacked timber backings such as the undersides of floor or roof timbers, or to timber lathing fixed to straps or studs.

Gypsum plasters

Gypsum was used by the Romans in Britain, was re-introduced to England in the thirteenth century and there is evidence of its fairly common use thereafter in areas where it occurred naturally. It cannot be asserted categorically, but there is currently no clear *evidence* that gypsum was used in Scotland before the eighteenth century. Plaster of Paris, originating from the large gypsum deposits under Montmartre in Paris, was probably the first gypsum plaster to be used in Scotland after Roman times.

Plaster of Paris is produced by heating calcium sulphate, $CaSO_4$, in mineral form - such as gypsum or alabaster - to drive off part of its water of crystallation. The powder obtained from this process forms a rapid-setting, hard plaster when re-combined with water and can be used on its own or combined with lime putty or lime plaster.

$$CaSO_4.H_2O + 1\tfrac{1}{2}H_2O \longrightarrow CaSO_4.2H_2O$$

$$\text{plaster of Paris powder + water} \xrightarrow{\text{setting}} \text{hard crystalline gypsum (set plaster)}$$

Fig.2 The gypsum cycle

Other classes of gypsum plaster, produced by burning at higher temperatures or by the addition of retarders, are well documented - for example in Mitchell's Building Construction - but are beyond the scope of this paper.

2.02 External plasterwork

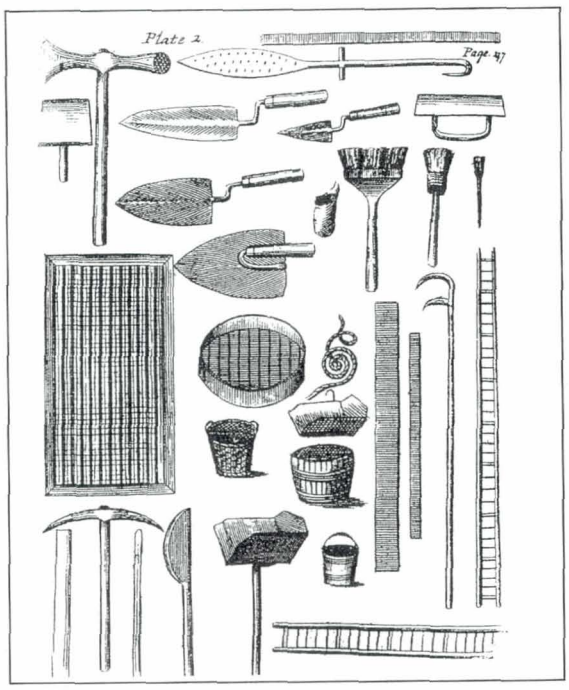
Before the twentieth century, in most parts of Scotland, local rubble was the cheapest available material for building masonry walls of all kinds. In situations of any importance, at least before the nineteenth century rubble walls were normally finished flush or covered over by plaster, which was sometimes 'lined out' to simulate ashlar, or finished with a thin roughcast coat, dashed, 'hurled' or 'harled' on to the prepared surface of the wall. These applied finishes improved the 'breathing' and weathering quality of the rubble, particularly where the basic material was an impervious rock, such as granite or whinstone. The general principles of external plastering or harling in lime are similar to those of internal plastering, varying only in the finishing. This subject will be dealt with in more detail in a future Technical Advice Note on external plastering, harling and limewash.

2.03 Lime plasterwork on masonry

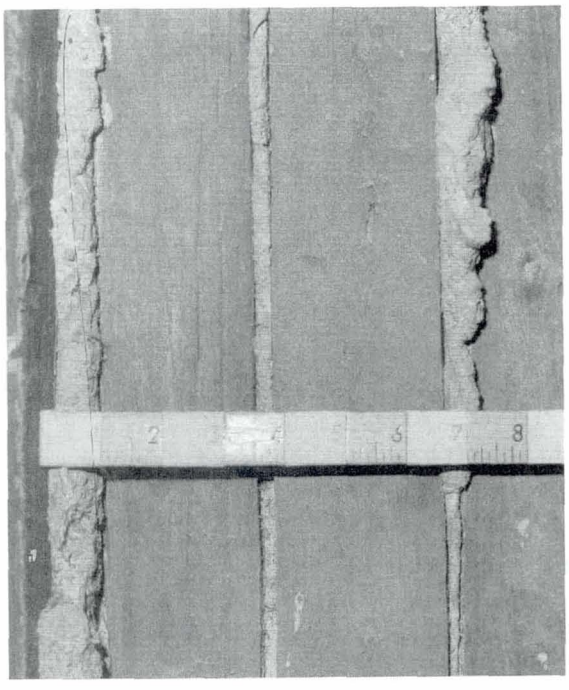
Only in modern times has it become fashionable to leave stonework exposed inside buildings. In earlier periods rubble or brick work would almost always have been covered by plaster which, along with any dressed stonework, would normally have been finished with limewash, distemper or paint.

The earliest lime plaster was applied directly to a masonry background of stone and lime mortar, that is 'on the hard'. The overall thickness of the plaster varied according to the number of coats applied, which was usually three (although single-coat work was common in and before the early seventeenth century). In general, the first and second coats - in this context known as the 'first' and 'straightening' coats - were no greater than 9mm ($^3/_8$in) thick, made up of a mixture of mature lime putty and coarse sand. The first coat provided the 'key', and the straightening coat(s) provided a true plane. The 'finishing coat' was smoother and thinner, usually 2-4mm ($^1/_8$in), containing only a little if any fine sand and a larger proportion of lime putty.

It would seem that until about 1600, lime plasters in Scotland contained no hair but that thereafter (as in England from the late sixteenth century) hair was commonly used as an organic reinforcement for background coats. Plaster containing hair was more flexible and consequently less inclined to crack than a straightforward mix of lime putty and aggregate.



3. Traditional plasterers' tools, from Moxton's Mechanick Excercises , London, 1703



4. Well-haired lime plaster on wide vertical laths, at 339-343 High Street, Kirkcaldy, probably c.1600 (scale in inches)

2.04 Lime plasterwork on lath

It was the introduction into Scotland of timber lath as a background material at the end of the sixteenth century which enabled the new plasterwork to be applied to both walls and ceilings, and timber lath survived as the standard background material for plasterwork until the 1930s. Traditionally lath was produced from straight-grained timber, riven or split into narrow strips generally about 9mm ($^3/_8$in) thick and 25 to 38mm (1in to $1^1/_2$in) wide, but they could be as wide as 100mm (4in) in early work. It was first produced from oak and sometimes beech, but later Red Baltic Fir was commonly used. It is not uncommon to find old floor or ceiling boards, sometimes painted, roughly split into laths. Lath splitting was carried out by plasterers as a source of income during the winter months; they also fixed the laths, which were spaced approximately 8mm ($^1/_4$in to $^3/_8$in) apart and held in place by wrought iron nails, about 18mm ($^3/_4$in) long. Often the head of the nail was turned over after it was driven to improve the plaster key.

The technique of plastering on lath was much the same as on the hard, except that the application of the first coat was necessarily different. The first coat - known as the 'scratch' coat in this context - of coarse plaster was applied diagonally across the laths and made to penetrate the gaps between them to form wet rivets or plaster 'keys'. After hardening these rivets supported the plaster coating. Usually two more coats of plaster - the 'straightening' and 'finishing' coats - were applied using the same material and technique for plastering on the hard.

Hair was again generally added to the mix to increase the tensile strength of the plaster which effectively had to be self supporting between the laths.

2.05 Run and moulded lime plasterwork

In general, plastering in early Scottish interiors was used only as a flat wall lining and it was not until plaster on lath was introduced as a ceiling material that surface moulding and enrichment were introduced. From the early seventeenth century, ceilings in the houses of the wealthier Scottish burghers and nobility became decorated with moulded ribs, straps and cornices, often with elaborate figurative ornament applied to the flat areas.

5. Run and moulded strapwork, with modelled bosses, Craigievar Castle, Aberdeenshire c.1625

Usually the cores of these mouldings were built up in situ in coarse plaster on lath on timber bracketting and the final profile run in fine plaster by means of a metal or wooden template mounted on a 'horse' and moved along a guiding timber rail. The template could be 'muffled' with felt or suitable material to form the base coats. Ceiling mouldings such as ribs or straps were often run over a background of iron nails (sometimes bound with twine) which were spiked through the background plaster along the intended line of the moulding. Small profiles were built up directly from the straightening coat which had been scratched to form a key. For simple regular mouldings, this technique continued virtually unchanged and in regular use until the Second World War, although fibrous plaster techniques took over for heavier profiles and gypsum (especially plaster of Paris) was later frequently added to the finishing coat.

Although some elaborate work would have been modelled by hand, most ornament, such as medallions, pendants, animals, flowers and figures, was formed on the plasterer's bench by beating stiff lime plaster into moulds of timber, iron or lead. A separating layer such as wax was sometimes applied to the mould to facilitate the release of the plaster when set. The ornament was then held in position using a thin layer of fresh plaster against the keyed plain background and supported until fixed. Pendants, probably developed from mediaeval timber roof bosses or stone pendants, were a particular feature of Scottish plaster ceilings in the early seventeenth century; they were usually formed around wooden or metal armatures fixed to the joists above. Lighter ornament was fixed with nails in addition to the adhesive layer of plaster. It is possible that more elaborate pieces of ornament were formed in situ by pressing a hardwood mould into position against a prepared background until the plaster had set (but trapped air would make this almost impossible unless the moulds were vented). By and large these techniques of producing ornament were superseded by cast gypsum technology in the late eighteenth century and by the more mechanical fibrous plaster methods in the mid nineteenth century.

6. Modelling stucco in situ

2.06 Lime stucco modelled in situ

The distinction between the stucco tradition and earlier decorative plasterwork in Scotland lies in the introduction of *high relief, wholly hand-modelled* decoration by skilled craftsmen *working in situ* in (usually pure) lime plaster.

Background coats of lime plaster containing hair were applied by the common plasterers, where possible directly on to masonry. In general, walls received up to four background coats and ceilings two, each coat finer than the last. After the first coat was applied, horizontal lines were scored into the plaster, outlining the position of cornice, frieze, architrave etc. Further undercoats of plaster, each finer than the last, were built up within this outline using timber bracketing where necessary to form a roughly modelled base for run mouldings. On to this background a thin layer of stucco was applied by the stuccoists. For mouldings, neat lime putty was generally employed, with, particularly later in the eighteenth century, a small admixture of gypsum, perhaps 1-3%.

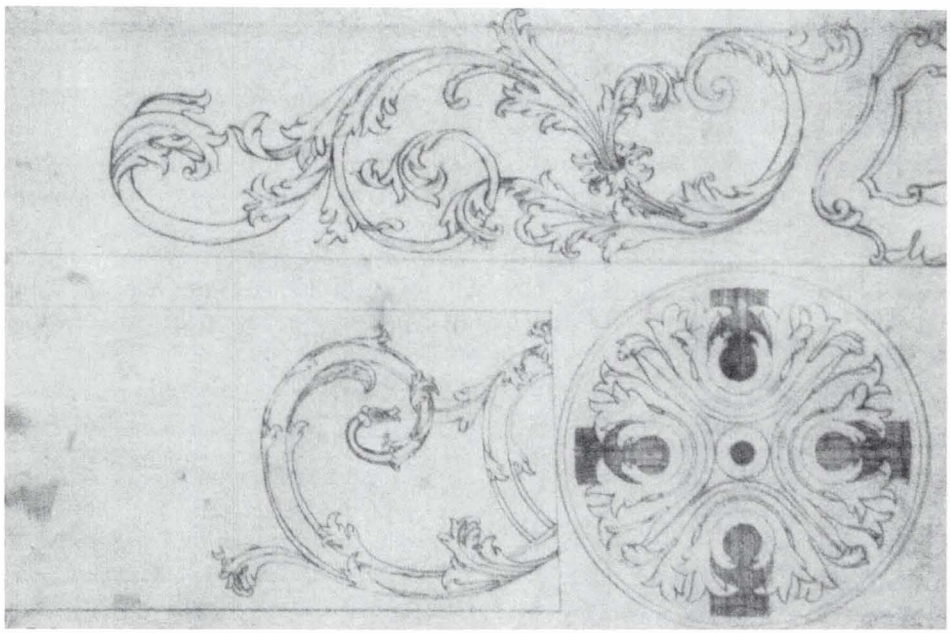
The addition of small amounts of gypsum to lime plaster mixes gives a useful increase in the speed of the initial set, and, since it expands on setting, helps to counteract the shrinkage of the lime and to reduce surface cracking. Occasional small amounts of hair and sand may have been included in moulding mixes, but the proportions found are often so small as to suggest that this was accidental. The use of additives to retard setting was necessary when gypsum was introduced: glue size, egg white, curd, skimmed milk, sugar-water and beer were commonly used, some also increasing the pliability of the stucco. The stuccoists would lay down lime putty to mature for years to produce the best quality material. Records show that at Blair Castle in 1748, Thomas Clayton used putty that had been stored at his cellar in Leith. The Italian tradition was to hand putty down from father to son!

The stuccoists used this fine material to run linear mouldings *in situ* and to model enrichment or ornament *in situ by hand*. The principal decorative techniques used with lime stucco work were:

bench moulding: generally used in the eighteenth century for enrichments to be applied to run mouldings in situ, and for repetitive elements such as modillions, egg and dart etc; the plaster was often removed from the mould before setting and cleaned up and finished by hand;

in situ moulding: where a hard die, often of lead, was applied to a roughly formed moulding, leaving a very sharply defined impression. This method was used for small repetitive elements and for working up fine detail on larger moulded elements;

freehand modelling: generally used for relief scenes, foliage, trophies, masks and so on, but some plasterers in the early eighteenth century seem to have used no moulds at all, preferring to model even the enrichments of cornices in situ.



7. Design for plasterwork, probably 1746 to 1752 by Thomas Clayton

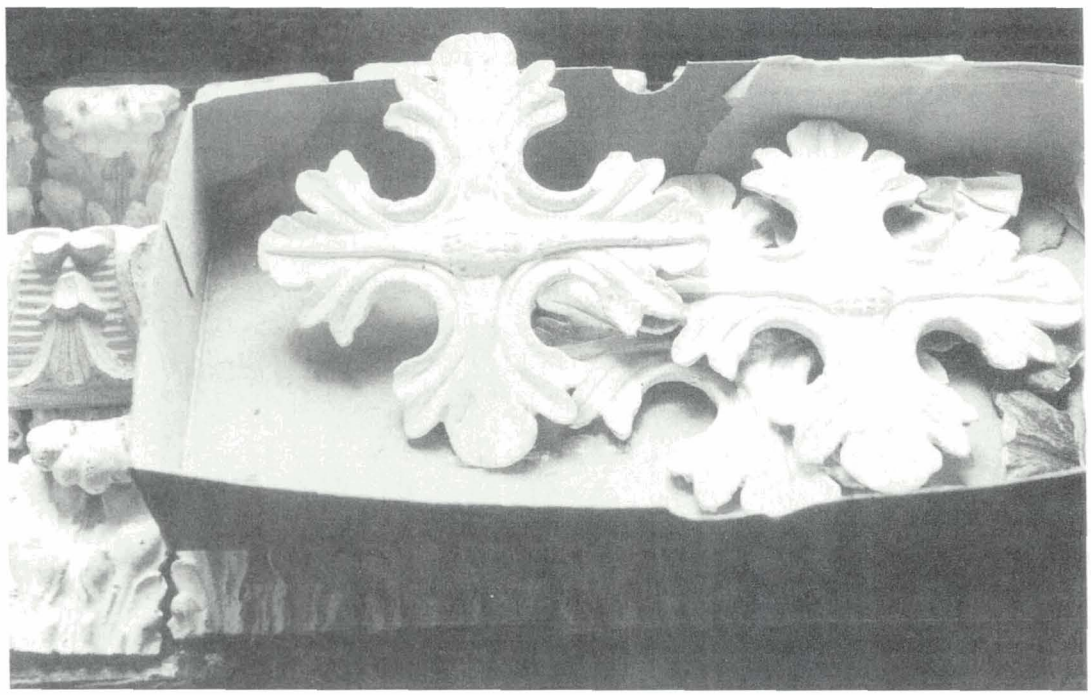
It is worth noting that from the examination, in 1983, of remnants of plasterwork surviving at Chatelherault, there was no evidence for the use of moulds or dies in the work of stuccoist Thomas Clayton, which was carried out between 1742 and 1746 (other than the brackets which seem to have been turned out of a plain mould and then further decorated by some quick incisions with a knife). The final stucco coat consisted of 2-3mm (1/8in) of almost pure lime putty (contaminated by a trace of less than 1% of gypsum), which may have been brushed on over the entire surface of the plasterwork following modelling. Small mouldings such as astragals were found to be run over deeply scored grooves in the final base coat which ensured that the mouldings had a sound key. Elsewhere the profiles of large decorative elements were sketched with a sharp point into the final base coat and then modelled wholly in situ in stucco. A grid was discovered scratched into a thin layer of stucco under a medallion head, on which a pencil sketch of the head had been superimposed. This had enabled the stuccoist to model the head in situ from a cartoon or print.

Where ornament projected in high relief, armatures of wire, nails, wood (even small branches and bones) were introduced as reinforcement.

Two methods of setting out the design are commonly found, depending on whether it was fully worked out on a drawing and transferred precisely to the plasterwork, or worked out at full size on the wall or ceiling, perhaps following a paper sketch which gave simply the main lines of the geometry. In the former case, the cartoon would be squared up, with a corresponding larger scale grid being imposed on the ceiling, either lightly scratched into the setting coat or set up with chalk or pencil. Using similar materials, the design could then be transferred from the cartoon to the ceiling. This method was particularly useful for small-scale work, for example modelling a medallion head from a print or even a sketch from life, and was indeed used in this fashion at Chatelherault. In the second case, the basic geometry of the design was set out on the ceiling, normally building up from centre lines and diagonals, with a pointed tool, the foliage and other detailed elements being sketched in a similar fashion. The spontaneity of this technique and the consummate skill of the stuccoists gave mid eighteenth century rococo work its essential vitality.

2.07 Gypsum plasterwork

The design and execution of *decorative* plasterwork underwent a significant change throughout Britain in the mid eighteenth century. The technique of using moulds to produce ornament which had been in operation over a number of centuries was developed for use with gypsum plaster to manufacture larger panels of ornament and linear enrichment for fixing to an applied background. The fashionable reproduction of delicate and precise neo-classical patterns on walls and ceilings, promoted by Robert Adam and his contemporaries after 1760, led to the publication of pattern books from which replicas of neo-classical detail could be set out for the plasterer to copy. The decorative element was first modelled full size in clay from the architect's detailed drawings. A reverse mould, obtained from a mixture of beeswax and powdered resin, was taken off the clay model. Rapid-setting gypsum plaster, or plaster of Paris, was mixed to a liquid consistency and poured into the open mould to the required thickness. Gypsum plaster expands on setting, so flexible wax moulds were used instead of the earlier rigid ones of wood, metal or plaster. In general this entire process took place in the plasterer's workshop. Preparations on site involved the application of well-keyed undercoats of lime plaster for flat panels and run linear mouldings. Where necessary the excess plaster at the edges of cast ornament and enrichment was trimmed off by the plasterer with a knife to produce an undercut edge or sharper impression. Finally the casts were set in position against the background using a thin adhesive layer of plaster of Paris.



8. New cast gypsum components for restoration work at Duff House, Banff, 1992

These developments in cast gypsum technology in the late eighteenth century had a significant impact on the extent of craftsmanship associated with the production of decorative plasterwork. The principal skill was concentrated in the limited number of 'ornament hands' employed in the workshop to produce clay models for reverse moulds. The tradition upheld by generations of master craftsmen in the production on site of plain and decorative plasterwork was about to give way to a new form of standardised practice. From the early nineteenth century gypsum plaster finishes used in conjunction with haired lime plaster backgrounds were in common use throughout Britain for interior walls and ceilings.

Much experimentation was carried out in the nineteenth century to develop new materials and additives. Portland cement was first used in 1824, Martin's cement (gypsum soaked in alkaline solution with sulphuric acid added) in 1834, Keene's cement (plaster of Paris and alum) in 1838 and Parian cement (borax, cream of tartar and plaster of Paris) in 1846. The last three were promoted for use in ornamental plasterwork. In addition fire resistant cements were developed for internal use, particularly in the aftermath of the destruction of the Houses of Parliament by fire in 1843. In the field of cast decorative plasterwork, attempts were being made to develop a mould which had more flexibility than wax, wood or plaster, the objective being to produce undercut ornament and enrichment previously unobtainable with more rigid moulds: at the Paris exhibition of 1851 gelatine moulds, developed for this purpose, were introduced to the market.

Plaster backgrounds also changed with the introduction of sawn lath in the middle of the nineteenth century (though wire lathing had been put into use in England as early as 1840). This led to the introduction of expanded metal lathing in the 1890s, which was extensively used by Robert Lorimer, and from which modern lath systems evolved.

2.08 Fibrous plasterwork

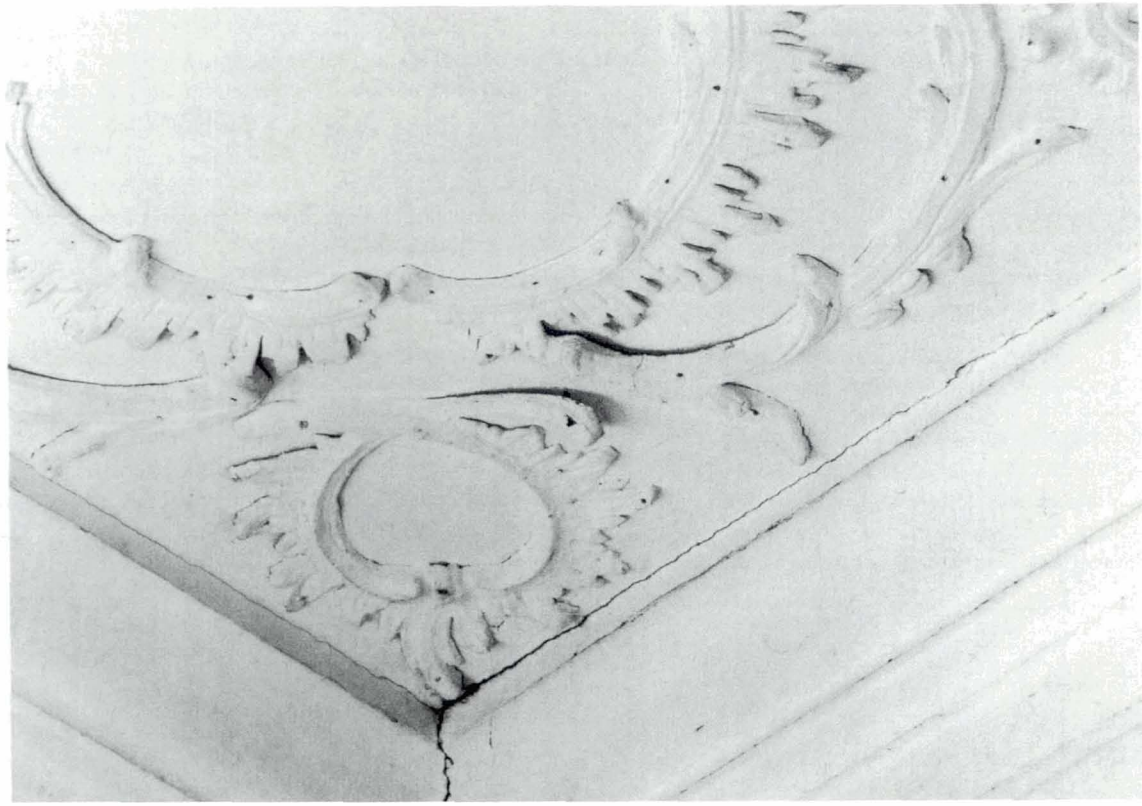
Fibrous plasterwork was introduced to Britain in the mid-nineteenth century after a French modeller named Leonard Desachy took out a patent in 1856. It is easily distinguished from earlier forms of plaster decoration by its lightweight pre-cast construction of thin layers of gypsum plaster reinforced with canvas or hessian and braced with wooden ribs or metal wires. Large sections of plaster surface complete with mouldings and enrichments could be precast as single elements and screwed into position. Fibrous plaster technology was particularly suited to the large public buildings of the nineteenth century such as libraries and theatres, where the surfaces of entire walls and ceilings including coves, domes, cornices and other enrichments, could be assembled from pre-fabricated panels manufactured in the plasterer's workshop. In Scotland, it was usual to combine traditional lime plastering on the flat walls and ceilings with pre-cast elements of fibrous plaster decoration such as ceiling roses, cornices and pilasters.

9. Fibrous plaster casting, at Chatelherault, 1984/5

Fibrous plaster formed the basis of all modern decorative plasterwork. It continued to be produced in gelatine moulds until the late 1940s when they began to be replaced first by PVC (developed by the film industry) and later by two-part silicon rubbers. In Edinburgh, the late Albert Cramb continued to use the traditional 'jelly' moulds until his retirement in the 1970s.

2.09 Papier maché, scagliola and compo

Various other new materials emerged in parallel with the new gypsum technology in the eighteenth century to meet the popular demand for the ornamentation and enrichment of interior walls and ceilings.



10. Papier maché decorative elements pinned to the plaster ceiling in The Chinese Room, Duff House, Banffshire, probably 1761

These included pre-cast *papier maché* ornament, which was used for example around 1760 at Auchinleck House and Duff House and in the 1770s at Inveraray Castle. Papier maché could be bought 'off the shelf' and was believed to be more convenient to apply and remove and more durable than either timber or plaster ornament. The quality of the paper used varied from fine tissue and sugar paper to brown paper, newspaper and even rags (the last only in the earliest examples) depending on the intricacy of the design. The paper was torn into strips and boiled to form a soft and yielding mash, and then boiled again with a strong solution of gum Arabic, flour paste or animal starch to form a thick liquid, sometimes thickened further with whiting to form an elastic dough. It was then poured or pressed into a greased mould, usually of boxwood and sometimes pre-lined with a few sheets of paper. The cast was left to dry before being fixed in place, often with iron pins which resulted in characteristic rust staining. As the material fully dried and shrank, it tended to curl and draw away from the pins, distinguishing papier maché from other materials. The surface of the papier maché was painted so that it became indistinguishable from the rest of the plaster ceiling.

Scagliola was a most effective method of imitating marble, formed by mixing plaster (usually Keene's cement) with size and pigments. It could be formed in situ, or pre-cast into panels for invisible fixing, and was finished by polishing to produce an effect which occasionally surpassed the real thing! It was used for example at Hamilton Palace (now demolished) and in a number of houses in Charlotte Square in Edinburgh.

The developments in plaster technology also led to the invention of *composition* or *compo* for forming delicate enrichment on timber backgrounds, for example on many of the chimneypieces - the commonly but incorrectly named 'Adam fireplaces' - of Edinburgh's First New Town. The term covers a number of recipes, but 'paste compo' was the most common. Quantities vary, but it was usually composed of resin, linseed oil, glue and whiting which formed a smooth, tough, elastic dough-like material which was pressed into hardwood, gypsum or brimstone moulds. The flexibility of the fresh material facilitated the reproduction of the finest detail. The compo ornament and the timber background were invariably painted together, so that the two could not be distinguished.

William Millar describes these various techniques, the materials and their manufacture and the late Victorian practice generally in *Plastering, Plain and Decorative* (1897).

2.10 Modern plasterwork

After the 1940s lime plasters were largely superseded in new work by cement-gauged coarse stuff or by the use of gypsum plasters or lime/gypsum plasters for all coats. Gypsum plasters had the advantage that they do not shrink on drying. They were available in four varieties: Class A, plaster of Paris (mainly used as a casting plaster); Class B, retarded hemi-hydrate gypsum plaster for mixing with sand in undercoat work (browning) and for use in top coat or board finishing work; Class C, anhydrous gypsum plaster, which had a longer setting period and produced a superior finishing coat and Class D, Keene's cement, a harder form of anhydrous plaster. Classes C and D are no longer available and since the 1950s the plain Class B plasters have been gradually replaced by pre-mixed varieties developed to meet particular requirements, such as light weight, fire protection, insulation, spray application, use on metal lathing etc..

Accessories such as expanded metal lathing and metal angle beads are frequently used with modern plaster in the place of the traditional timber lath and beads.

The development of plasterboard almost eliminated the need for plaster altogether. Formed from a core of gypsum plaster set between two heavy sheets of paper, plasterboards could be used either as the backing for a finishing coat or for a very thin 'skim' coat of gypsum plaster, or on their own with slightly hollowed joints taped together and filled to form a complete dry lining system. Plasterboard laths, like thin strips of plasterboard, were also made as a substitute for timber laths.

3.00 CONSERVATION

3.01 General

Architects, conservators and craftsmen working with historic plasterwork should be clear what it is they are trying to achieve. It may be helpful to distinguish between the physical *fabric* of the plasterwork and its abstract *design*. The first objective should normally be to *repair* the authentic fabric, not to destroy and renew it. If the plasterwork is damaged or decayed, it *may* be appropriate to restore it, that is to alter it or add to it, to make it conform again to its *design*. In some circumstances, where, for example, elements of plasterwork - the *design* of which is known, or can be *reconstructed* from documentary and/or archaeological evidence - are missing from an otherwise fairly complete interior, it may be appropriate to *renew* those elements as part of the *repair* and *restoration* of the interior as a whole. Generally all work should be carried out with the minimum possible intervention and with the maximum possible retention of the original fabric.

Before deciding on a strategy for *repair* or *restoration* of plasterwork, the architect must first identify and understand the age and importance of the plasterwork and the materials and techniques with which it was made, diagnose defects and recognise their underlying causes. A detailed survey and inspection will be necessary before drawing up a specification for repair and/or restoration. The best quality stucco work will transcend mere craftsmanship, being sculpture of considerable importance, and should be treated as such. Repairs should be carried out, or at least guided, by a conservator, as should repairs to papier maché.

Renewal of plasterwork using clearly identifiable modern materials and methods may occasionally be justified, but such an approach is beyond the scope of this paper which is concerned with techniques of *repair* and *restoration*.

Repair and *restoration* work should be carried out in materials which ultimately match the composition and strength of the existing (or in some special cases using weaker sacrificial materials). New work should *never* be stronger or denser since this can actually encourage deterioration in the existing fabric, either by transferring stresses from the harder repair material or because moisture-borne contamination such as salts will concentrate at boundaries, the weaker material giving way first. *None* of the modern plastering materials and techniques are suitable for repairing historic plasterwork and their use should be strictly limited to new work; neither is plasterboard. The various proprietary accessories such as metal angle beads and stop beads are also unsuitable for use in historic buildings. Traditional plasterwork was simply sweetened by hand at corners or, as the use of timber lath developed, it was taken up to a radiused timber angle bead. Modern hard-setting plasters should never be combined with traditional plasters because of the significant relative difference in hardness, suction and porosity. Plasterboard is incompatible. Pure plaster of Paris, although used in its own right traditionally, is too stiff to be used for patching or repairing pure lime plasters. Modern cellulose-reinforced proprietary fillers are similarly unsuitable. If existing work requires strengthening or consolidation, it should rely on mechanical fixings wherever possible, and if need be on traditional organic materials such as size and shellac. Modern adhesives such as epoxy resin, PVA etc should generally be avoided, although if used sensibly with understanding and care, PVA can be used diluted (1:10 with water) to control the suction of surfaces during conservative repairs. Unless there is very good reason to change, existing evidence should always be followed in terms of overall thickness, number of coats and composition of each coat when *restoring* or *renewing* plasterwork, and as far as possible *repairs* should always be carried out on a like-for-like basis.

Where plasterwork is secure or can be propped, all necessary work to structural timbers such as beams, ceiling joists, strapping etc should be carried out from above or behind with minimum disturbance to the plaster. Traditional methods of timber repair are desirable but should be carefully considered to avoid interfering with the plasterwork: there will be occasions when steel repairs will result in less destruction of original plasterwork. Structural repair must be completed before repairs to plaster begin. Chemical treatment for dry rot or woodworm should be avoided wherever possible, it is essential to avoid using oil-based chemicals which may leave greasy deposits on nearby plaster and painted decoration, and to apply any liquid carefully by brush rather than by

uncontrolled spray, injection or infusion. Even water-based chemicals may sometimes leave stains. A carefully considered *environmental* approach to the control of dry rot will be less likely to damage plasterwork and other finishes and may be generally more appropriate.

Where lath or other timbers are to be renewed care should be taken over the type of preservative, if any, to be used. If preservative treatment is required a waterborne system should be chosen and the timber should be thoroughly dry before use. The use of spirit based preservatives is not recommended.

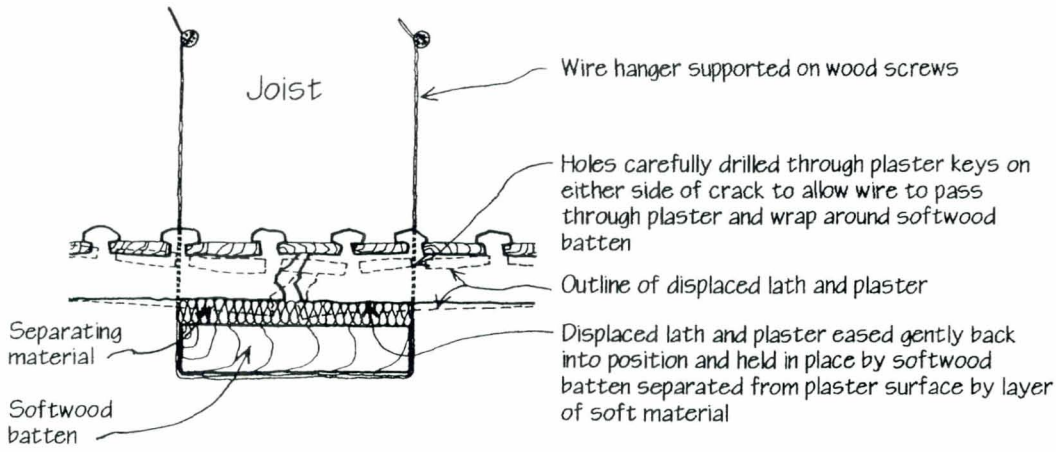
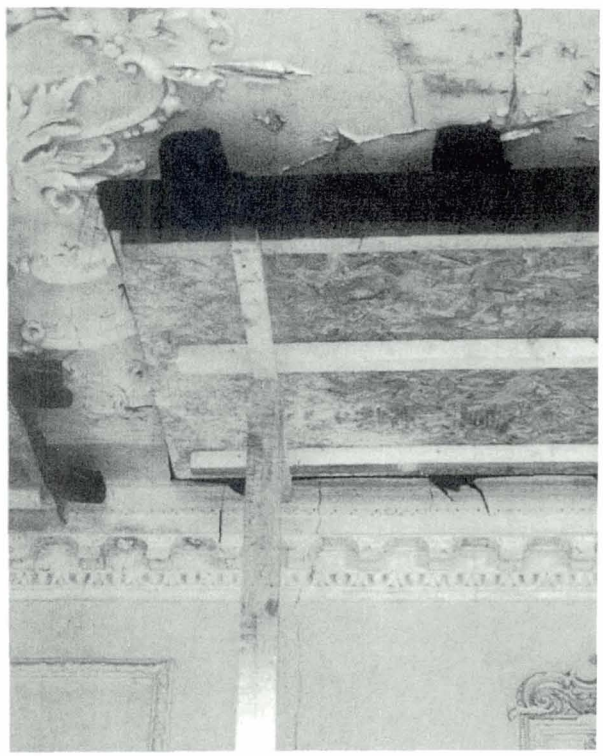


Fig.3 Method of providing local temporary support to ceiling plaster

Ceiling repair requires very careful lifting of floorboards in the area above the damaged plaster. When repairs are complete, hammering of floorboards can cause serious damage to the repairs and must be carried out with great care: the boards should not be fixed until the repair is fully dry and the ceiling should continue to be propped from below until they are re-fixed. Drilling and fixing boards with countersunk screws will prevent undue vibration, but may not be aesthetically acceptable.

If ceilings need to be shored to prevent collapse, adjustable props (to take the load firmly without stressing or damaging the plaster) may be used in conjunction with plywood panels and timber battens positioned clear of the base of plaster ornament. A thick isolating layer of soft material such as underfelt, straw-filled sacks or foam rubber must be sandwiched and firmly packed between the timber and plaster faces. Small sections of ornament may be secured through the plaster by wire loops or coach screws fixed to the timber background. Large ornaments such as ribs, bosses or pendants may be temporarily supported by loops of wire carefully threaded through the plaster and hung from the timber structure above. These techniques may be adapted to support an entire ceiling, if necessary, while the joists above are entirely removed. Any screw or wire fixings which are likely to become permanent should be of stainless steel.



11. Emergency propping of a ceiling using thick rolls of soft material supported on plywood platforms, built off softwood framing

3.02 The mechanisms of decay and failure

Problems with historic plaster result most commonly from external factors, the unwanted presence of moisture being by far the most common fundamental cause. Most lime and all gypsum plasters will eventually disintegrate in prolonged damp conditions (although pure lime plaster can last almost indefinitely and has been excavated on archaeological sites in surprisingly good condition). Dampness dissolves and mobilises any salts that may be present from existing contamination or introduced for example by the injudicious use of cement. Once in solution, capillary action wicks the salts through porous building materials where at junctions, surfaces and voids they are free to re-crystallise. If trapped beneath the surface of the plaster or decoration, their growth exerts a steadily increasing pressure that may lead eventually to the spalling of plaster coats. At a micro level, plaster is weakened and broken by the expansion of the crystals. (Vapour-permeable paints permit salts to pass through them, allowing the salts to crystallise on the surface where they can be brushed away without harm rather than causing crystallisation damage behind the paint layer). If gypsum, which is slightly soluble in water, is subjected to protracted moisture movement in one direction, it will lose some $CaSO_4$ in solution, which will recrystallise elsewhere, leading to material loss from one area and growth in another.

Inherent defects in the plaster itself will be encountered most frequently in recent replacement work which is carelessly specified or poorly executed: understanding of the failures of replacement work in historic buildings is no less important than an understanding of the original historic material for the architect, tradesman or conservator.

Defects may be *physical*, e.g. caused by dampness, too much or too little suction etc., *chemical*, e.g. caused by salt contamination, or *mechanical*, e.g. caused by sticking a foot through the ceiling!

Symptom	Defect in the background	Defect in the plaster
Cracking	Movement or disturbance of load bearing walls or failure or excessive deflection of floor or ceiling joists, stud partitions etc. whether due to underlying structural reasons, excessive floor loads, fungal attack, insect attack etc will almost always cause cracking in plasterwork, although the tensile strength in a well-haired plaster on lath has often proved sufficiently strong to hold together an otherwise failed partition. Cracking is usually deep and wide, often displacing the surface on either side of the crack. Cracking may be due to differential movement between different sorts of background, for example where lath is stopped either side of a solid beam. This is common in new replacement plaster and should be avoided by using canvas scrim to reinforce the junction. Cracking may occur where there is local or differential separation of the plaster from the background.	Minor cracking in old plaster is not generally a serious problem, but due often to old movement or early shrinkage. Cracking in new replacement plaster may be due to shrinkage from using too wet a mix or from inadequate compaction. Lack of tensile strength can be due too little hair in the mix, or inadequate distribution of the hair. Cracking may occur where there is local or differential separation of coats.

Symptom	Defect in the background	Defect in the plaster
Crazing	Not usually associated with defects in the backing	Not generally a problem with old plaster unless it has actually caused the plaster to fragment and become loose or it has affected applied decorative work. Modern replacement lime plaster will craze if the background is too dry, exerting excessive suction on the new plaster, if the sand is not sufficiently sharp or if the various coats are not sufficiently well scoured and compacted, although this can be remedied by scouring even a few days after the plaster has been applied. A very small admixture of gypsum may help to avoid crazing. Crazing in the first or scratch coat does not need to be scoured because it improves the key for the straightening coat. Very fine crazing in plaster will also be filled if coats of limewash are to be applied before the final decorative finish.
Separation of coats	Not usually caused by defects in the background	Excessive moisture may cause coarse background coats to soften and decompose behind the finishing plaster and decorative mouldings. In replacement work it is usually caused by inadequate keying of the earlier coats, inadequate preparation of work before applying later coats, eg failure to dampen down sufficiently.
Separation from background	Inadequate keying of a masonry background or excessive suction caused by inadequate wetting of the wall. With work on timber lath, this may be due to the laths being too closely or too widely spaced, or lath nails rusting away after prolonged water penetration, or mechanical damage to plaster keys. May be caused by vibration or movement of the background.	Use of an unsuitable mix, especially lack of hair in the first coat on timber lath.

Symptom	Defect in the background	Defect in the plaster
Bulging	Bulging usually but not necessarily indicates an extreme case of separation of coats or separation from the background, although this is not necessarily the root cause. It may be caused by structural movement as for cracking, and also by eg timber decay or insect attack in the lath or other timber supports and bracketting. Mechanical damage such as collapsed deafening boards, or debris falling down behind strapping may cause local bulging.	Bulging may indicate that top coats have separated from first coats, due usually to inadequate keying of the earlier coat, to the use of incompatible materials, or to the expansion in wet conditions of plaster with a high gypsum content
Partial or total collapse	Collapse is usually the result of total separation of coats or separation from the background. Once the keys have broken over an area of say 1 - 2 sq. metres (1.2 - 2.4 sq. yards), the weight of the unsupported plaster can cause slow progressive failure at the margins and a dramatic and extensive collapse several months after the triggering event. After major water penetration (i.e. storm damage or fire damage) plasterwork on lath may not show any obvious defects immediately. The lath expands as its moisture content increases and cuts into the plaster keys: this usually holds the plaster firmly in place until the laths dry out, leaving cracked keys and unsupported plasterwork. This can result in spectacular collapses with no forewarning, months or even years after the initial event.	Collapse of the top coats, leaving the first coats securely in place, is usually due, as above, to inadequate keying of the earlier coats. Collapse of Edwardian or later lime plaster ceilings may be due to a lack of hair in the plaster.
Crumbliness	Can be due to the breakdown of the plaster after prolonged water penetration and salt contamination.	Vegetation and fungi such as dry rot can destroy the integrity of plaster by the penetration of roots and substantial mycelial growth. In the event of fire, the friable coarse background coats of lime plaster eventually disintegrate, leaving the harder outer coat collapsed and fragmented but usually capable of withstanding heat to retain the profile of its moulding and ornament. In recent replacement plaster crumbliness may be due to inadequate lime in the mix, to inadequate preparation and maturing of the plaster mix or to over-rapid drying.

Symptom	Defect in the background	Defect in the plaster
Efflorescence	Caused by salts (commonly associated with rising damp) which accumulate in the areas where evaporation occurs and crystallise on the surface of the plaster. The presence of hygroscopic salts in the plaster, i.e. ones which by their nature actually attract moisture from the atmosphere, can cause efflorescence even in new plaster which has been applied onto salt-polluted masonry thus sometimes creating the illusion that the rising damp itself still persists. Salt contamination may also be associated with condensation within flues, with ill-advised previous water-repellent or biocidal treatments, with animal husbandry and with some industrial processes. Temporary sacrificial coats of lime plaster or clay poultices may be used to draw harmful salts out of a wall.	In new replacement plaster efflorescence may occasionally be caused by salt from contaminated sand.
Staining	Staining may be caused by the rusting of the ferrous fixings of laths and structural timbers, by salt contamination from various causes (see above), by the transference of dirt via water penetration, by surface mould growth due to condensation (particularly on gypsum plaster) by smoke, by the use of inappropriate paints etc., or by chemical fungicide or insecticide treatments.	In new work, staining may be caused by impurities in the sand.
Fungal growth	Caused fundamentally by the unwanted presence of moisture, whether wet or dry rot caused by prolonged water penetration or moulds caused by condensation.	Fungal growth itself may not necessarily cause any problems to the plaster, for example the mycelia of dry rot growth may cover the surface of plaster but may simply be brushed off - however the underlying water penetration will almost always have resulted in problems which require attention.
Flaking of surface decoration	May be caused by dampness and salt contamination. Internal finishes may be affected by changes to the exterior treatment of the building, especially where this inhibits the rate of evaporation of moisture through the wall.	May be due to an incompatible paint finish or inadequate drying time.

Most defects affecting plaster will also affect any applied decorative finish such as paint or paper; dampness is a particular threat to decoration. If work of importance or significance is affected, emergency treatment should be given to the decoration by a specialist conservator while the source of moisture is investigated and brought under control.

The application of an impermeable decorative finish such as oil or emulsion paint on lime plaster which has not had time to carbonate fully, may itself cause problems because the setting of the plaster will be impeded and the finish may be damaged by the residual construction dampness trapped behind. Any oil-based paint applied to an alkaline surface will be attacked and the oil turned to a soap. Full neutralisation of the plaster through the carbonation of the lime is required before any oil-based finishes can be applied. Limewash may be bound fast, but distemper, commonly found, is likely to have had a weak binder and may have become dusty: it must be removed completely before attempting to redecorate with limewash, distemper or other paint. Defects in decorative finishes will be dealt with in more detail in a future Technical Advice Note.

Surviving plaster in unroofed or ruined buildings is subject to specific attack from weathering, pollution and organic growth. Exposed plaster edges are vulnerable to rain and frost action which may cause detachment from the background, the separation of coats and general disintegration. Acid rain and general pollution will have a long term effect on the stability of lime plaster; lichen and moss will secrete organic acids which will soften plaster surfaces and cause decay. Problems of this nature cannot be tackled without the advice of a conservator with appropriate knowledge and experience.

Papier maché is particularly vulnerable to dampness: the dry and therefore highly absorbent paper sucks in moisture, causing loss of shape or separation from the background. Damp papier maché is an attractive habitat for insects and fungi. Embrittlement of the glue with age also causes loss of shape. The outer coats of paint may effectively protect the material from external moisture such as condensation, but may, on the other hand seal in moisture, causing damage.

3.03 Survey and inspection

The objectives of a preliminary inspection are broadly fourfold:

Firstly to determine the age and composition of the plaster, and the technique by which it was applied: the age of plasterwork maybe by its style, character and context and sometimes with considerable precision from documentary sources such as building accounts. It will also be important to consider archaeologically its position in the sequence of development of the building; this will normally need to be determined by observation, especially of the grounds on which it is formed and of their relationship to the rest of the building fabric. From this primary evidence, correlations with documented campaigns of work can be made. Simple visual inspection will reveal much but it may be necessary to open up carefully in local areas to determine the method of fixing, thickness and number of coats etc.. The advantages of investigation should be weighed against the consequences of destruction, however minimal. 'Sounding' the plaster with the side of a clenched fist will reveal whether walls are plastered on the hard or strapped (the latter sounding more hollow). Where mouldings, enrichments and other forms of decoration are present, it will be necessary to try to identify the methods by which they were formed: whether they have been run in situ, cast on the bench, modelled in situ by hand or formed by a combination of these techniques. Analysis of the overlying paint layers may also provide information on the plasterwork.

Lime plaster may be differentiated from gypsum plaster by its more obvious texture (particularly so if it is gauged with sand, but also true for pure lime work): lime is visually denser and heavier. Materials analysis may be necessary to determine the mixes used and whether, for example, there was any addition of gypsum. A sample for analysis should weigh at least 500 gms (1.1 lbs) and should contain each layer of plaster from background to finishing coats. A selection of suitable laboratories is listed in Appendix 4.01. The destruction caused by investigation, where detached samples are not already available for other reasons, should be carefully weighed against the potential value of the information to be gained: proportions of gypsum and lime identified by analysis will not necessarily provide an appropriate specification for renewal or repair techniques.

Lime stucco work may be superficially identified from several characteristics:

- it will generally predate the late eighteenth century;
- in situ freehand modelling, especially rococo work, will almost invariably be in lime stucco rather than gypsum;

- enrichments, even when moulded, will have a 'lively' surface rather than mechanical precision, and generally a boldness of execution;
- even where the lime putty is used without aggregate (as is often the case with moulded enrichments), stucco has a much higher density than cast gypsum;
- surfaces resist scraping with a finger nail, and a detached moulded element will ring almost like china; cast gypsum can be, by contrast, 'dead'.

Whilst Section 2.00 of this Advice Note attempts to give guidance as to the earliest date of introduction of various materials and techniques to Scotland, the trends were set generally in the most sophisticated buildings, and the older methods and simpler styles carried on far later, varying with local tradition, status and so on, often into the twentieth century.

Documentary evidence may exist in estate muniments, the National Monuments Record for Scotland and so on, either relating specifically to the plasterwork or, for example, to alterations which may assist in dating work. However, correlation with extant work may well not be clear or straightforward.

Secondly to determine the significance of the plasterwork artistically, architecturally and historically; this is likely to follow on from the first objective, but should also take into account its provenance (is anything known about the architect or craftsman?), the possible existence of painted decoration on plain plaster (which particularly in mediaeval and sixteenth and seventeenth century work should always be suspected), the unusual nature of any ornament, the quality of workmanship, rarity of survival locally or nationally, and so on. Apparently plain or crude plasterwork is not automatically less valuable or more expendable than more sophisticated decorative work. Relief and painted decoration may be of the highest artistic or historical value.

Thirdly to record profiles, ornament, and other features; measuring and recording profiles often requires a great deal of skill and interpretation since mouldings may be clogged with paint and it may not be appropriate to clean the paint off or to remove a section for closer inspection. Classical profiles in cornices and other ceiling ornament were sometimes distorted from the pure mathematical shapes to alleviate foreshortening or to give particular visual effect. Profile combs are not usually sufficiently precise for accurate recording.

Good photographic recording is essential: a full photogrammetric survey of an elaborate ceiling may occasionally be desirable, but a grid of photographs all taken at a level plane with a perspective-correcting lens will often be as useful. The general condition, the degree of risk and the likely nature of repair work will determine the level of accuracy required in measurement and photography.

Fourthly to establish what defects exist and to what extent, and to determine what has caused them; a visual inspection should identify cracks, crazing, bulging, sagging, collapse, crumbliness, efflorescence, staining or surface fungal growth. The eyes may be backed up by the other senses particularly touch: simple touching may reveal springiness, loose ornament or the presence of moisture; tapping plaster on the hard may reveal areas which are boss (sounding hollow); gentle pressing may discover detached sections on lath (a broom handle wrapped in a soft cloth may prove useful for testing ceilings, but only if used with care!): even tasting may be useful to prove the existence of salts, but care should be taken if the presence of lead paint is suspected. (Indeed the Health and Safety legislation warns that all painted surfaces should be assumed to contain lead unless it can be proved otherwise: the same common sense approach should be applied to arsenic in wallpapers, toxic compounds from timber preservatives, fungicides etc.)

Some opening up may be necessary but this should be kept to a minimum and carried out with care. The use of a fibre optic borescope or endoscope may enable the back of wall plaster to be investigated with minimum disturbance. With ceilings it is usually relatively easy to gain access from above, but care should be taken to avoid damage to the feathers on tongued and grooved floorboards, and there may be deafening and deafening boards to be removed as well. Great care should be taken to avoid vibration or debris falling onto the top of the plaster while opening up is in progress. All dust and debris should be removed from between the floor joists or dwangs (branders) with a vacuum or a soft brush used only along the direction of the lath to avoid damaging the plaster keys. Opening up should permit an inspection of the structural timbers and their bearings, as well as the rib and cornice bracketing, fixings, timber laths and the plaster keys themselves. A large part of one important mid eighteenth century Scottish ceiling fell without warning when the poor quality estate timber hangers, by which the dwangs were connected to the joists above, failed due to insect attack. A litter of broken pieces of plaster on top of the lath is an indication of trouble. If a ceiling is thought to be at risk, it should be carefully propped before any opening up takes place.

In examining plasterwork it is extremely important to recognise that centuries of settlement and movement within a building can distort the appearance of plaster finishes: distortion and irregularity in the plaster surface is not necessarily a sign of weakness or potential collapse.

An electrical resistance damp meter may be useful for recording comparative degrees of dampness; where (occasionally) an absolute measurement of moisture content is required a specialist laboratory can drill a small sample of plaster and test it by the carbide method. The degree to which hygroscopic salts exist may also be tested by laboratory analysis if a superficial survey is not conclusive. In the absence of specific defects in the plaster, the existence of dampness *per se* is not sufficient justification for renewal.

Ceilings require special care simply because of the gravity (literally!) of a potential collapse. They should first be inspected from below, and extreme care should be taken if failure of structural timbers is suspected. Trestles or a scaffold tower may be required to inspect the plaster at close quarters. Seriously damaged ceilings may require emergency propping before a useful inspection can take place (see 3.01 above).

If significant painted decoration is suspected, which is obscured by dirt, staining, smoke damage, or by later paint layers, the surface should be examined by a conservator before the preliminary inspection is completed.

The inspection of Roman, mediaeval or other early or particularly rare plasterwork may require to be undertaken by a suitably experienced and skilled conservator who should make detailed recommendations for its protection and repair. The names of such conservators may be obtained from the Historic Scotland Conservation Bureau.

Drawings may be useful to clarify the extent of defects, or the degree to which they are interrelated.

Where original plasterwork is missing from an historic interior, the restoration of which is considered desirable in the context of a conservation strategy for the building as a whole, layouts of ornament and enrichment and detailed profiles may need to be provided. This may require a combination of documentary research and the careful examination of surviving adjacent work.

3.04 Contractual issues

Architects and contractors are strongly advised to ensure that only tradesmen who are familiar with the application and techniques of traditional plastering are appointed to undertake repair and restoration work in lime plaster: the majority of plasterers trained in Scotland in recent times will have had no experience of working with lime plaster or of plastering onto timber laths. Whilst the techniques may appear to be simple and thus within the grasp of any plasterer, it must be remembered that the mixes and methods are easily misunderstood and are not merely a matter of specification, but of experience, understanding and genuine craftsmanship. In certain circumstances consideration might be given to the involvement of a suitable skilled and experienced craftsman in a teaching, consultancy or supervisory role. The names of suitably experienced tradesmen may be obtained from the Scottish Conservation Directory or from the Historic Scotland Conservation Bureau. It may be advisable to seek samples of workmanship of the type represented in the contract from a range of plastering firms before a contractor is selected. If the plasterer lacks modelling skills - as is likely - a modeller or a conservator may be required to form models or moulds for the reinstatement of damaged or missing ornament, or to repair or model stucco work in situ.

Well before a contract is let it is advisable to contact specialist suppliers for advice on the delivery of traditional materials. NB. Lime putty for plasterwork must be matured for at least 60 days and the coarse or fine stuff ideally for a further 60 days (absolute minimum 30 days) before use: this may necessitate pre-ordering or an extended contract period.

All necessary structural repair should be attended to before plaster repair work begins. Background voids and surfaces should be carefully and thoroughly cleared of all debris and dust by gentle brushing and vacuuming in advance (see comments in section 3.03 part 4).

In the preparation of a contract programme, allowance should be made for adequate drying out time between the application of lime plaster coats: this is likely to be at least two weeks but will depend very much on local site and climatic conditions and the experience and judgement of the plasterer on site will need to be relied upon. Lime plaster on laths is initially very slow to 'take up' and harden, especially the scratch coat. A plasterer can build up more quickly on the hard because of the increased suction of the masonry, even after thorough wetting, but eventual drying out will be slower and more unpredictable than on laths. Gentle heat or dehumidification may need to be provided if plastering is taking place during the winter months (but avoiding direct or excessive heat

which will cause shrinkage cracks). All areas of newly repaired or reinstated plasterwork must be given adequate time to dry out before initial decoration takes place, and certainly twelve months before any oil-bound paint is applied. Limewash can be applied within a couple of weeks and seems to bind better if the plaster has not dried out completely, but may slow down the carbonation process.

However well-known and trusted the contractor may be, the architect should always include in the specification for samples of materials (lime, sand, gypsum, coarse stuff, fine stuff, hair, lath etc.) and samples of workmanship (templates for mouldings, run profiles, moulds and casts) to be approved before work commences. In some cases it may also be necessary to approve sample panels of repair techniques before work is committed.

If a contractor's fixed price for plain lime plastering is no higher than for modern work, he is almost certainly ignorant of the standards actually being required. Plasterers who are re-learning the traditional techniques may take twice as long to plaster a plain wall in lime than in contemporary hardwall plasters: the on-cost should reduce as plasterers gain confidence, but there will always be a premium on quality traditional work.

3.05 Materials

Lime

The criteria for lime putty recommended in Historic Scotland Technical Advice Note 1: "Preparation and Use of Lime Mortars" will apply in the production of lime plaster except that the finest quality of lime is selected. For slaking, only lime which is fresh, non hydraulic, has been properly calcined (neither overburnt nor underburnt in the kiln, so that it will break up rapidly and effectively when combined with water) should be used. Slaking must be carried out carefully and thoroughly to avoid leaving small particles of unslaked lime in the mix. The slaked lime should be passed through a fine sieve which prevents any sediment from being transferred into the fresh supply of lime putty. Lime putty for finishing coats of plaster requires finer sieving than that for background coats. Where possible lime putty and sand should be mixed and matured together as coarse- or fine stuff before application. As a basic rule lime putty should be matured for at least *60 days* (whether on its own or, preferably, in the form of coarse or fine stuff) before use in plastering. Maturing is required for three reasons:

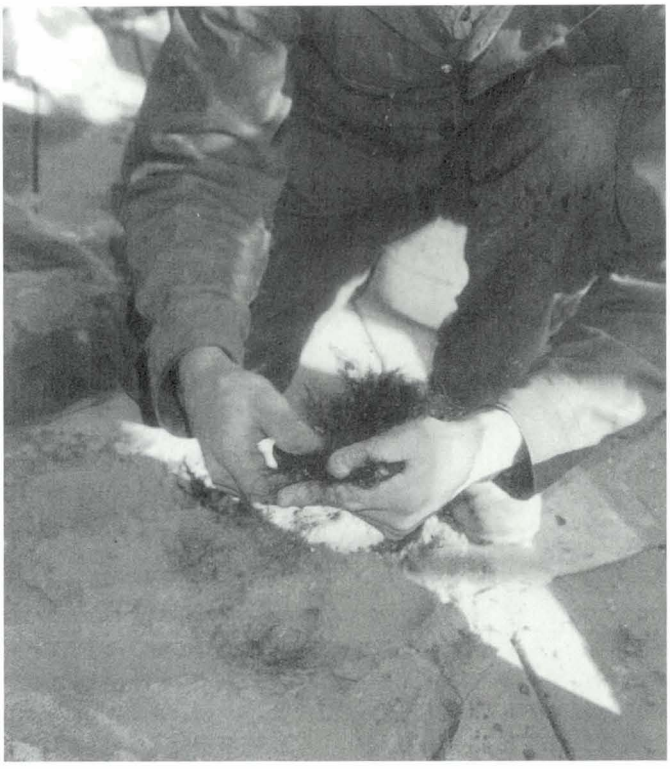
- Putty itself requires time to ensure slaking is fully completed. Even tiny unslaked particles can cause pitting and popping of the plaster surface in situ.
- Storage and maturing of the putty encourages the lime particles to break down to smaller sizes and improves the plasticity and workability of the plaster, whilst reducing the requirement for water in the mix. This is known as 'fattening up'.
- Maturing of the lime putty and sand, as coarse stuff or fine stuff, encourages the development of a good bond between the putty and the sand grains. Mature lime putty and ready mixed coarse- and fine- stuff can be purchased from specialist suppliers.

Sand

Sand should be selected to match the grades of aggregate in the various coats of original plaster, approximately 1-6mm for the first or scratch coat, 1-3mm for the straightening coat(s) and 0.5-1.5mm for the finishing coat. It should be sharp, well graded, well washed and should contain no silt or salt contamination.

Coarse stuff and fine stuff

The mature lime putty should be well mixed (so that all the voids in the aggregate are filled) with the appropriate sands for background and finishing coats and stored as wet plaster ('coarse' stuff or 'fine' stuff according to the size of the aggregate) with the air excluded for a further 30 days *minimum* before use. The need for careful preparation of lime putty and its incorporation with aggregate cannot be stressed too much: ramming, chopping and beating are a laborious necessity and use should be made of a paddle or mortar mill.



12. Teasing out hair, before mixing with coarse stuff

Hair

Where hair is required for background coats, it should be long (min 25mm, max 100mm; 1 - 4 in) strong, soft and not springy, and free from grease or other impurities. Washing in limewater will remove any excess lanolin.

Goat hair is accepted as the best variety readily available. Cow and also imported yak hair is also suitable. Upholstery horsehair from mane and tail is too smooth and wiry but horse body hair can be suitable if it is long enough (i.e. post winter grooming or clipping).

Before mixing, the hair should be well teased out to break up any lumps. Hair should never be combined with the lime putty/aggregate mix before storage because it will degrade over time from alkaline attack. It should be added and well distributed through the mix near the time of application. In general it is not advisable to mix hair and coarse stuff with a mortar mill since this can give rise to difficulties in achieving the correct distribution and may even damage the hair. Hair and pre-mixed hair plaster can be purchased from specialist suppliers.

Lath

All new timber laths should, where appropriate, match the original in terms of whether split or sawn, species of timber, thickness, length and spacing. They should be formed from straight grained heartwood. Where no original work survives to copy, the use of sweet chestnut or Scots pine, split not sawn for greater strength and stability, will normally be appropriate; and will generally be 30-38mm ($1^1/_4$ - $1^1/_2$ in) wide and 5-6mm ($^1/_4$ in) thick and in lengths of approximately 1500mm (1.6 yds) or, where shorter lengths are required, 1200 or 900mm; fixed with 18mm nails to dwangs or strapping at max 350mm ($13\ ^3/_4$ in) centres; with a 9mm ($^3/_8$in) gap between laths (the thickness of the plasterer's thumb); butt jointed at each end with a 3mm ($^1/_8$in) gap to allow for expansion along the length of the lath when moisture is absorbed from the plaster; and with the joints staggered to avoid a continuous joint. Bundles of split lath should be used together so that irregular edges are parallel. Traditional split lath can be purchased from specialist suppliers. Timber laths should not be treated with a solvent-based preservative. If treatment is considered necessary use a water-borne system and ensure the laths are fully dry before use.

Lime plaster should not generally be used in combination with expanded metal lath (which offers no suction and can cut through the plaster key before setting). Nevertheless well-haired lime plaster applied with great care to stainless steel lath can be usefully exploited for conservative repairs where the renewal of timber lath could result in increased loss of the original material.

Fixings

Mixing different metals in the vicinity of plaster containing gypsum can lead to electrolytic action which in turn can lead to salt contamination and the breakdown of the plaster. Since plasterwork almost always contains iron (in lath nails and so on) it is unwise to introduce any other metals. Because moisture in the plaster can cause rusting in iron fixings use stainless steel or equivalent material. Blued tacks (as carpet tacks) are sometimes used for fixing laths.

Lime water

Lime water is a useful component of lime plaster repair. Its uses include feeding and strengthening of existing lime plaster and 'wetting up' to prevent over-rapid suction of moisture from new plaster into old. Lime water is produced from the settlement of 'milk of lime' directly after slaking or, less satisfactorily, by stirring lime putty into a tub of water which is then made airtight and left to stand until the water is no longer cloudy. The lime water should be siphoned off without disturbing the putty at the base of the tub and without including any surface crystals. If the water becomes cloudy in the process it must be allowed to stand again until clear. The limewater should be used as cold as possible to avoid any crystallisation problems.

Timber for grounds, fibrous plaster etc.

Always use the species (most probably, softwood) and dimensional sections to match the existing. Softwood may sometimes need to be preservative treated but this should be specified with care to avoid the problems of staining, as noted in Section 3.01.

3.06 Renewal of plain lime plaster on masonry

The plaster should be applied in a minimum of three coats, typically as follows:

Coat	Thickness	Composition	Hair (if appropriate)
First coat	8 - 10mm ($^3/_8$in)	1:2.5 or 3 lime: sand measured by volume	Varies according to type of hair used, about 2 kg/m^3 (3.4 lb/yd^3) for goat hair. When examining the blobs pulled out on the tip of a trowel for regular and even distribution of hair, a maximum of 1mm apart is a good rule of thumb.
Straightening coat	8 - 10mm ($^3/_8$in)	1:2.5 or 3 lime : sand measured by volume	Less than first or scratch coat or sometimes omitted
Finishing coat	3mm ($^1/_8$in)	1:1 to 3:1 lime: sand measured by volume.	None

The background should be prepared by clearing away old loose material from the face of the masonry, and raking out the joints only as necessary to provide sufficient key, and by thoroughly wetting up to reduce the suction - that is to ensure that water is not drawn out of the wet plaster into the dry masonry too rapidly. If the rubble background is very uneven or in poor condition, the surface may need to be dubbed out or brought forward in stages by filling with coarse stuff and pushing and hammering in small snecks and pinnings, in such a way as to ensure that the thickness of each coat of coarse stuff is nowhere greater than the thickness of a little finger (10mm; $^3/_8$in). When the wall is ready for plastering, it should be a more or less straight plane, with the larger stones and only some of the snecks and pinnings still exposed.

Each coat of lime plaster, including dubbing out where used, must be allowed to dry before the next coat is applied in order to provide sufficient suction. The recommended interval *between coats* is one to three weeks but this will vary according to temperature and humidity. If sufficient time is not allowed for plaster to dry and harden between coats, shrinkage, crazing and delamination of coats will result.

The larger areas of mortar should be scratched, larger smooth stones might need to be stugged to provide a decent key, and the whole wall then wetted again before applying the first or scratch coat with a steel trowel. When firm but not set, the surface should be lightly scratched, without cutting through, with a lath scratcher or similar wood-toothed instrument to provide an undercut key for the next coat. Where additional thickness is required, further coats must be applied, each no more than 10mm ($^3/_8$in) thick and each thoroughly wetted and keyed as described.

After sweeping off any dust and further wetting of the dried surface, the straightening coat should be applied, and when it has set sufficiently, the wall should be wetted again and then vigorously 'scoured' or compacted with a wood float; this necessary at least twice and sometimes even four or five times, not just to level the work but to consolidate it as it shrinks on drying. This process is essential if cracking and crazing in the finished work are to be avoided, and its importance is often overlooked by plasterers inexperienced in the use of lime. Providing the sand used is really coarse and sharp, the final scouring leaves a good open-grained finish which is itself sufficient key for the finishing coat; alternatively delicate keying with a fine nail float may be necessary.

For the straightening coat in the best quality work, plaster 'dots' or 'dabs' should be applied to the first coat and then plumbed and levelled to form 'screeds', using long timber 'floating rules'. When the screeds have sufficiently hardened, the areas between should be filled with plaster, applied with a trowel. The plaster should then be levelled off with a 'darby', a long two-handled wooden float with its ends bearing on the screeds, until a perfectly straight surface is obtained.

After yet further wetting of the dried straightening coat, the finishing coat should be applied in two layers (or three in the best quality work) and it too should be scoured, taking care not to overwork any particular area: at this stage any minor imperfections can be patched by scouring small quantities of fairly dry finishing stuff into the surface. In sophisticated work, the final surface should be polished with a steel trowel.

The extent of scouring and compaction required is subject to debate and, in any case, is likely to vary with differences in background, drying conditions, etc.

Work in a vernacular context should follow the basic principles outlined above, but with less emphasis on achieving a truly level or plumb surface.

The classic account of plain lime plastering is given in the earlier editions of Millar's *Plastering, Plain and Decorative*.

13. Running a cornice in situ

3.07 Renewal of plain lime plaster on lath

The procedure for plastering onto timber lath is identical to that described for masonry with the exception of the application of the scratch coat. The lath background should be thoroughly wetted up and the plaster applied across the laths using sufficient pressure diagonally and in one stroke to force it through the gaps in between to form a mechanical key. The scratch coat needs to be left longer before keying for the next coat because there is less suction from the laths than from masonry. New plaster may be applied to old lath successfully providing the lath is in good condition and has been thoroughly cleaned of all old plaster, dirt and debris, and well wetted beforehand.

Where a wall is to be newly strapped to receive lath and plaster, it is sensible to remove all original timber, e.g. dooks and bilgates, from within the masonry construction: these are vulnerable to dry rot and should be replaced with non-ferrous vine eyes to anchor the new strapping.

3.08 Renewal of run profiles in lime plaster

A sheet tin or zinc template matching the negative profile of the original moulding should be used, mounted on a wooden housing termed a 'horse' which is run along the line of the moulding or cornice guided by a wooden rod fixed temporarily to the wall or ceiling. To match run work generally of all dates, background coats of coarse lime plaster no greater than 10mm ($^3/_8$in) thick should be run using a 'muffle', formed by padding out the template. As previously described, each coat should be well keyed and prepared before the next is applied. For small profiles, the work can be built up direct on the plain scratch coat: for larger girths it should be applied to laths on bracketting or to screws used as necessary in the same way as the original spikes and following the original pattern. The finishing coat is generally no more than 3mm ($^1/_8$in) thick. If enrichment is to be fixed to the run moulding the finishing coat should be scored before setting to ensure a good key.

3.09 Renewal of moulded enrichment in lime plaster

Where moulded enrichment in lime plaster is to be reproduced in the authentic way, it cannot be cast like gypsum since, without air, the lime cannot set. A reverse pattern mould can be produced as originally, by carving the negative enrichment in timber (boxwood is used nowadays). This particular skill is generally no longer possessed by the plastering trade and it may be necessary to turn to woodcarvers or to the pattern-makers of, for example, the cast iron trade. Alternatively, if existing decoration is to be matched, a 'squeeze' may be taken, from which a gypsum replica of the original is formed, from which a reverse mould may be cast (the mould cannot be cast directly from the original without causing damage).

The squeeze may be taken in situ (useful if most of the original remains intact, or if work in a comparable building is to be used as a source for missing design) or on the bench (much more convenient if complete sections of broken ornament survive, or if, for other reasons, sections have had to be removed). Small squeezes are quite simple to take; large ones, up to a practical maximum of about 1200mm square, are possible, but they can be awkward and may require elaborate support until set. Where an impression is required from an even larger area, the edges of adjacent squeeze panels should be marked for matching in the workshop and the height above datum of each corner should be recorded to ensure accuracy in reassembly. It is essential to clean the surface of the original ornament back to the bare plaster finish to obtain an accurate impression (see section 3.16 below). The squeeze is then formed by painting on a number of coats of latex, reinforcing with muslin scrim and allowing each coat to dry until a smooth surface is formed. An outer case is then built up in scrim and plaster of Paris. When the case has set and has been removed, the latex is peeled off and placed in the case ensuring that it holds its shape. Into this squeeze, the 'preliminary cast' or gypsum replica may be cast. The replica should be removed when firm but not set, and modelled as necessary by hand to produce an exact match of the original. For moulded lime plaster, a reverse mould should then be cast from the replica in a rigid material such as glass-reinforced plastic.

Once the mould is made, it should be well-oiled (to act as a separator and to prevent the plaster distorting the mould if it is timber). The lime putty, or fine stuff with or without hair, should be mature and stiff, with minimal water content. After chopping and beating thoroughly it should be pounded well into the mould, building up the mass but avoiding any layering or core/surface separation which will lead to weakness. When fully pounded, and after perhaps 15 to 20 minutes, the work is turned out and left on the bench to set before fixing. In the context of stucco work, the moulds may be turned out more quickly and manipulated by hand, altering, for example, the set of petals on rosettes so that no two are exactly the same, or, more subtly, so that they are adjusted to suit the direction from which light will primarily fall.

Where the enrichment was originally fixed direct to the background, this should be copied using countersunk screws and gauze washers in place of the original wrought iron nails. Where enrichment is to be applied on top of plain plaster or run profiles, the finishing coat may be omitted to allow the moulding to be set in place with a thin adhesive coat of wet plaster (pure lime putty or, if gypsum was used eg in later stucco work, a mix of about half and half lime putty and plaster of Paris): the back of the enrichment may need to be scratched in the mould, and for heavier elements, mechanical fixing may be necessary in addition to the adhesive layer.

3.10 Renewal of lime stucco modelled in situ

The renewal or reinstatement of large areas of stucco work will require the expertise of skilled modellers to reproduce wholly hand-modelled, high relief ornament in situ.

For insitu modelling, lime putty (more plastic than the very stiff mix used for bench moulding), normally with the addition of hair and gypsum, should be applied as a rough shape to the background work, most frequently to an internal angle of a running moulding. This is then impressed, usually diagonally, with a hard die. This technique can produce fine detail with great sharpness and clarity, and by the use of two superimposed dies considerable undercutting can be achieved. There is also the advantage of full integration with the background, into which the die normally slightly penetrates. This technique is also useful where the mouldings and their enrichments must diminish, as for example with a coffered dome imitated in false perspective on a flat ceiling. Dies for this work were generally of lead in the eighteenth century; the same material, which can be carved with steel tools, will serve today, with modern plastic materials as alternatives.

An alternative to the traditional techniques for setting out freehand modelling, particularly where reinstatement must be undertaken based on accurate evidence from a rectified photograph or photogrammetry, is for the drawing to be printed in sections on thin paper and pounced through to the plasterwork. Whatever technique is used for setting out, the decoration must then be worked up in three dimensions, generally in two coats, and particularly with rococo work the material must be applied in confident decisive strokes of the trowel. It is important in replicating this work that such a technique is developed, rather than attempting to build up the designs by the repeated application of small amounts of plaster. Mixes for this work will generally be in the order of 1:1 fine aggregate to lime putty, frequently with the addition of some gypsum primarily to control shrinkage cracking. More gypsum is likely to be added to the core layer of enrichment, typical mixes being 6:7:3 sand:lime putty:gypsum for the base coat and 7:8:1 for the setting coat. The setting coat may be prepared to receive the freehand enrichment by scratch keying in addition to the setting out sketches. Heavier elements should be formed around screws driven into the background plaster, generally at an angle to the horizontal. Larger work requires a more substantial armature such as mesh (which is flexible and readily modelled) on screws .

In reinstating a badly damaged or totally collapsed ceiling, all reasonably reusable material should be reset, both in the interests of authenticity, and to ensure that the quality of the new work matches that of the original. Normally, moulded elements either detach themselves during collapse or are readily detached from the remains of the bedding mouldings, and can readily be refixed as they originally were, after conservation if necessary. Some salvage of in situ die-impressed enrichments is likely to be possible on a similar basis.

The most difficult elements to reincorporate are undoubtedly parts of freehand moulded work. If this is robust and has detached itself or can readily be detached from the background plaster whilst retaining its integrity, it can be refixed after conservation by mechanical means to the new ground, as well as by the use of an adhesive layer occupying the thickness of the setting coat, which clearly needs to be cut away to accommodate it. It is important in such cases to ensure that the flow of the design is not disrupted, leading to disjointed, shaky curves. Where the design is worked in shallow relief, or part merges with the setting coat of the ground, a different technique needs to be followed if substantial panels have survived, for example attached to collapsed sections of flooring after a fire. The technique here is to reinforce the face of the plaster, and then to divide it into manageable sections with incisions through the face. It can then be separated from the laths and backing by, for example, working a saw horizontally below the surviving laths. Small sections, once inverted, can be pared down to an overall thickness of no more than about 10mm. The new ceiling is prepared by completing the normal background plaster, and then cutting away the floating and setting coats to the thickness of the conserved plaster plus a few millimetres for an adhesive layer, which will normally be of gypsum. Larger sections will need to be backed with stainless steel mesh set in gypsum plaster, and mechanically fixed in prepared holes in the background work, which can then be made good to conceal the join.

3.11 Renewal of gypsum plaster

The manufacture and application of lime plaster background coats for gypsum finishes should follow the procedure already described for plain lime plaster. Similarly the procedure for in situ run linear mouldings in gypsum should follow the traditional method already described for lime; in no circumstances should these be replaced with precast sections of gypsum plaster.

For finishing coats, Class A gypsum, ie plaster of Paris, (with an added retarder if necessary such as glue size or sodium citrate) should be used rather than the proprietary retarded Class B gypsums ubiquitous in modern construction. The proportion of lime to gypsum should generally match the original except that modern plaster of Paris is more consistently dehydrated and therefore stronger than its traditional counterpart, and it may be advisable to reduce its quantity if the mix is to match an existing one. If no evidence exists to follow, lime and gypsum should be used in equal parts. Gypsum plaster should *never* be scoured since the water kills the plaster set and weakens the body of the material.

Where it is necessary to renew a defective section of cast gypsum plasterwork, the damaged area must be carefully cut out by hand and the boundaries of the remaining sound plaster work kept straight and square. The background should be cleaned down and all redundant fixings removed in preparation for the reinstatement of the plaster finish.

Cast gypsum decoration is reproduced by mixing plaster of Paris with water to form a uniform, lump-free liquid which is immediately poured into a flexible reverse mould to set. Setting time can be as short as four minutes, although it can be retarded by adding size. It is essential that the mould material is flexible enough to accommodate the minor expansion which takes place while the plaster sets. The traditional gelatine moulds have to be frequently melted and re-formed or clarity of detail is lost. Nowadays vinyl moulds (a hot process) are commonly used although they are limited to about fifty castings. White silicon rubber or liquid polysulphide moulds (both cold processes) are also suitable and will last much longer. It is essential to adhere strictly to manufacturer's instructions in the production of moulds, application of releasing agents for casting etc in order to avoid imperfections in the finished cast surface.

Existing cast ornament or enrichment can be matched by the squeeze/preliminary cast/reverse mould method described in section 3.09. Where this method is not practical the reinstatement of original ornament will involve the production of a clay or carved wooden model to match the original from which the flexible reverse mould can be cast.

Linear repetitive ornament and enrichment should be cast in short lengths or sections (generally no more than 300-400mm (12 - 16 in.) long). This allows maximum flexibility in distributing the cast decoration evenly and symmetrically along its background and facilitates mitering at corners etc. Joints between sections of linear ornament should be positioned to allow the pattern of enrichment to mask the plaster joint. The rear surface of cast ornament should be prepared to adhere to the background by scoring or forming a lug by knife or hand as appropriate before the plaster fully sets. It is essential to differentiate between the separate elements in the original cast assembly. Some large features of gypsum ornament were integrally cast from one mould eg a ceiling rose or section of frieze. Smaller enrichments eg modillions or rosettes, were often individually cast and applied to the surface of larger ornament, run moulding or plain plaster. Individual enrichments of this nature may need to be undercut to match the original by careful hand trimming with a knife between setting and fixing.

Large elements of cast ornament should be fixed in position by means of countersunk screws fastened through the background coats to the framing beyond. After fixing, the holes surrounding the screws should be wetted up with size water to avoid suction and softening of the plaster, and then stopped with a plaster/size mix. Similarly where junctions occur between individually cast sections, their edges should be wetted up with size-water and the joint stopped. Small items of cast ornament should be fixed to the scored floating coat of wall or ceiling or the scored finishing coat of an in situ run moulding by means of a thin adhesive layer of plaster of Paris (used pure or mixed with lime putty), against which the casting is pressed and propped until bonded. Once the cast enrichments are fixed in position the finishing coat is applied to the plain areas of wall and ceiling against which the ornament stands in relief.

When plasterwork incorporating cast gypsum enrichments is damaged, its repair can usually be accomplished by detaching and conserving the cast elements and resetting them on new grounds if necessary. Such cast components are probably the easiest elements of historic plasterwork to re-use, even after fire damage for example.

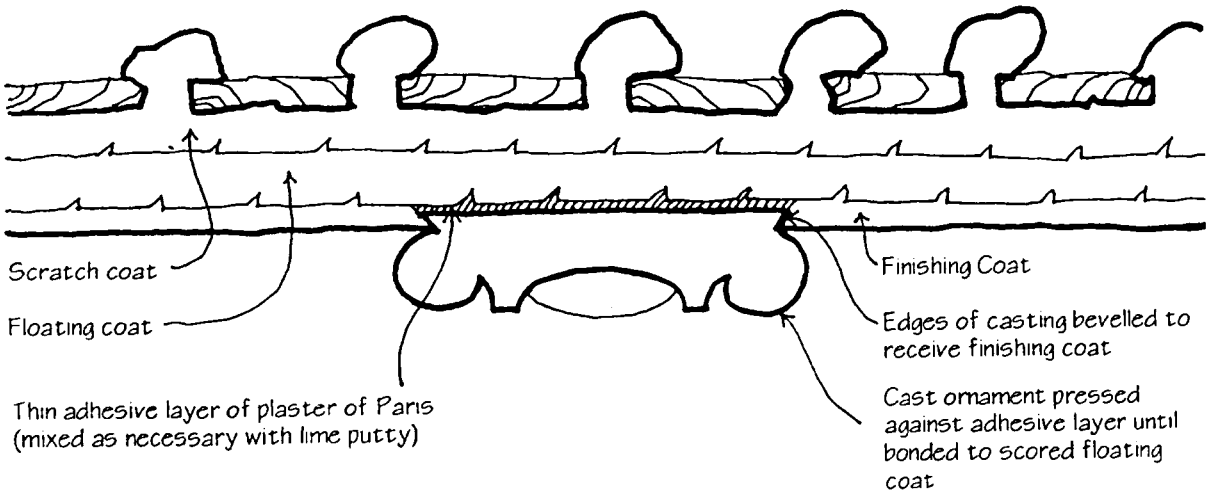


Figure 4. Fixing of small cast gypsum enrichments

3.12 Renewal of fibrous plaster

For repairing or re-instating fibrous plaster decoration, a flexible reverse mould is required, just as for ordinary cast gypsum work.

All fibrous plaster casting should be carried out in plaster of Paris and requires careful preparation in advance, including the production of moulds, correct gauging of plaster with size or 1% sodium citrate solution, and careful measuring and cutting of canvas sheets and strips of timber lath.

A thin coat of pure plaster of Paris is brushed onto the back of the mould followed, before setting, by a second coat, known as 'seconds' which has been gauged with size. At least two layers of canvas strips (e.g. 6mm mesh jute hessian) are spread across the entire surface area of the casting before the second coat has set and the last layer immediately brushed again with seconds. The prepared timber laths are then dipped in seconds and laid on top. (The laths are laid flat if the casting is to be fixed directly to a timber support and on edge if it is to be suspended on wires e.g. in a ceiling.) A final layer of canvas sheets is wrapped around and over the laths and brushed over with the seconds before the casting is left to set.

Depending on the original assembly, small items of repetitive ornament or enrichment may need to be cast separately and applied to the basic fibrous plaster profile. These enrichments may either be bedded in the reverse mould prior to casting the main panel or be fastened to the finished casting by means of a thin adhesive layer of plaster of Paris or concealed countersunk screws. A detailed description of cast, fixed and bedded enrichments for fibrous plaster is contained in Millar's *Plastering, Plain and Decorative*.

The method of fixing fibrous plaster panels will depend on the background material. In general, panels supported off a timber background should be fastened with countersunk screws, wetted and stopped as for ordinary cast decoration. It is good practice to form a 6mm ($^1/_4$ in) deep x 25mm (1 in.) wide rebate at the edge of all plain fibrous panels so that junctions with the adjacent panels can be stopped with hessian scrim and finished with a plaster/size mix. All joints between fibrous plaster castings and plain lime plaster should be stopped with a mixture of plaster of Paris and size. Wide or deep joints should be filled with scrim and plaster.

3.13 Plaster repair techniques

Small patches and cracks

Large cracks and patches need to be prepared by undercutting the edges with a sharp chisel (for plaster on the hard) or a fine knifeblade or handsaw (for plaster on lath, taking care not to cut the lath) to form a dovetail key. The area may need to be widened until its edges adhere tightly to the background. Before plastering, all loose material, dust and dirt should be thoroughly removed by careful brushing and vacuum cleaning and the

surrounding area should be treated with size or possibly a weak 1:10 PVA solution. Lime plaster may be thoroughly wetted up with lime water which will feed and firm up the old plaster and also reduce the suction: excessive dryness of old plaster may necessitate persistent wetting until the surface is truly damp. The background should be prepared and the patch built up in coats of no greater than 10mm ($^3/_8$ in) thick to the depth of the surrounding plaster using the technique described in section 3.07, ensuring that with lime plaster the necessary time is taken for each coat to set. Small cracks may be similarly wetted up and filled with lime putty combined with a small amount of fine aggregate such as silver sand: this custard-like mix is best applied with a soft brush to get into all the crevices.

Damaged or missing laths and keys

Before any repair work can commence, the back face of existing plasterwork must be carefully and thoroughly cleared of dust, loose particles etc. by brush and light vacuum cleaning.

Lath which has lost its fixing can be reconnected using wood screws and pairs of large diameter washers as follows:

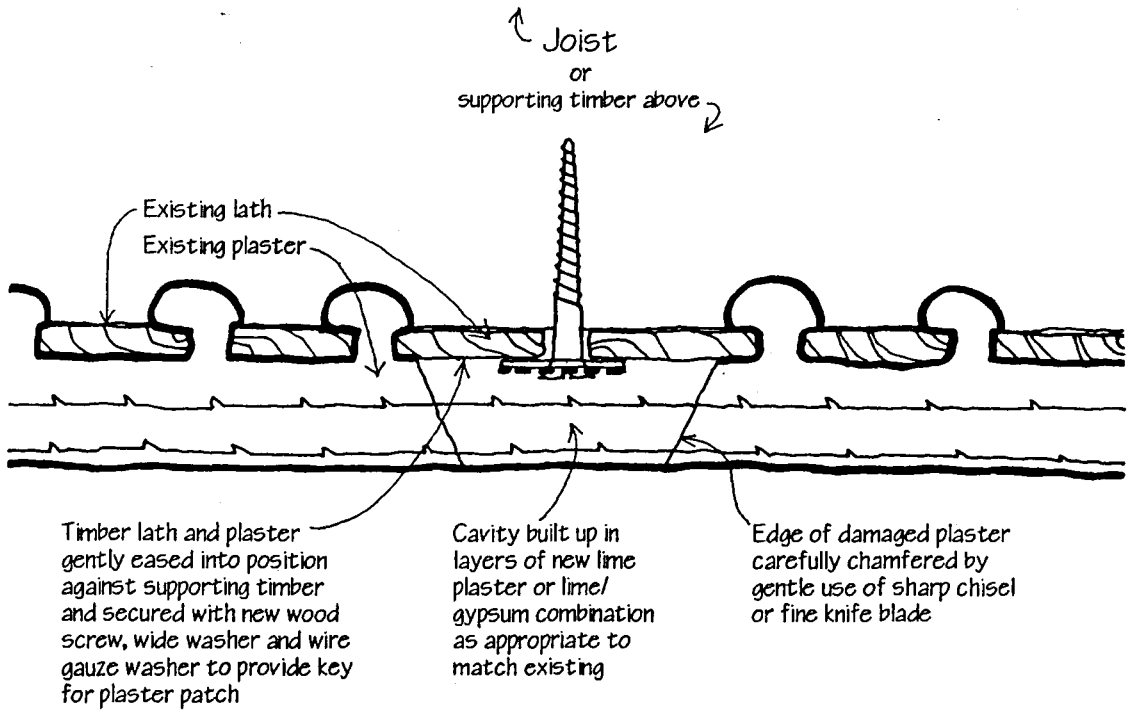


Figure 5. Sound laths pulled away from supporting timber

The new plaster in the above detail relies on the key formed by dovetailing the existing material. In some situations it may be prudent to reverse the splay so that the new plaster helps to support the old, in which case additional screw fixings may be necessary to support the new work.

Where lath is broken or defective it should be carefully sawn and snapped out from between its supports. The area of plaster surrounding the gap in the lath should be thoroughly wetted with a weak size or PVA solution before repair takes place. Small gaps may be reinforced with wire and plaster as follows:

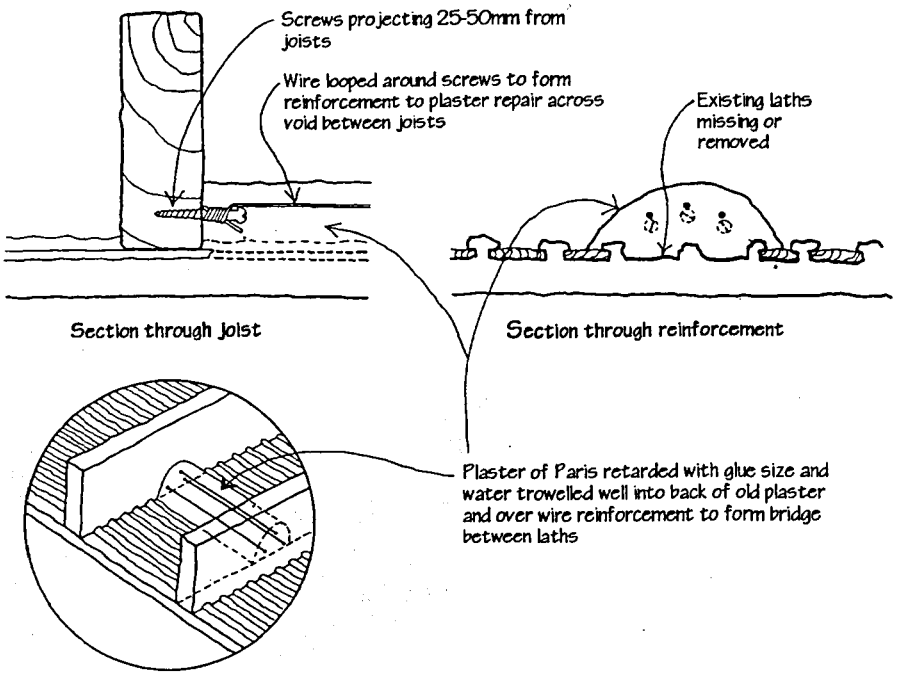


Figure 6. Small local repair to ceiling where laths are damaged or missing

Large areas of missing lath or broken or missing plaster keys should be thoroughly wetted up as before and repaired with wire mesh and plaster as follows:

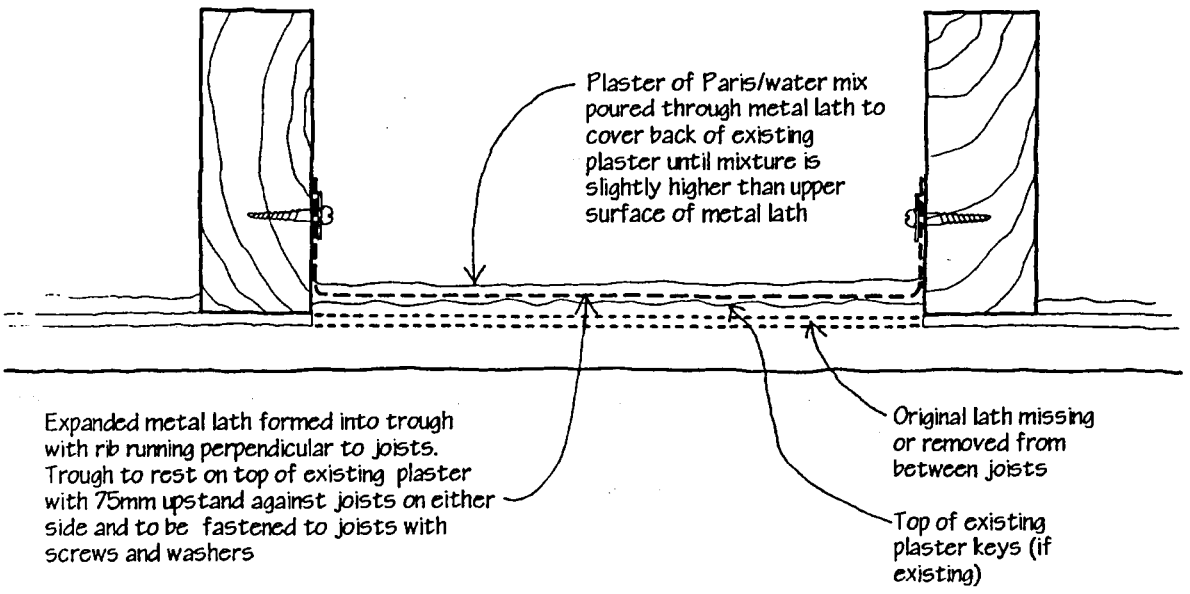


Figure 7. Ceiling repair from above to large area of broken or missing laths/keys

NB. Each section of new plaster reinforcement should be allowed to dry completely before embarking on similar repair to an adjacent section.

Failure of timber cornice bracketing

Where timber bracketting or grounds have failed, it is possible to re-support the run moulding as follows (this technique can be adapted to failures in support timbers generally):

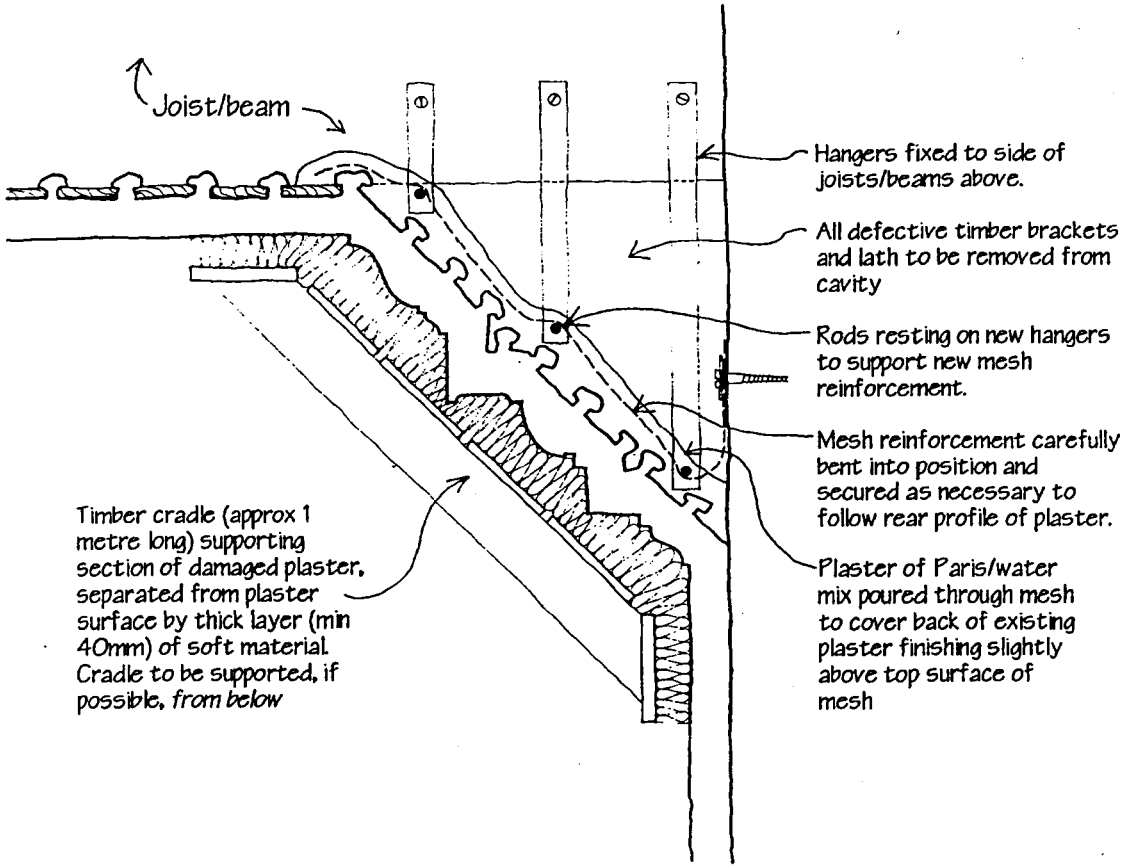


Figure 8. Repair from above where support timbers have failed

3.14 Papier maché repair

All repairs to papier maché, or removal of paint from it, should be carried out by or under the close guidance of a conservator.

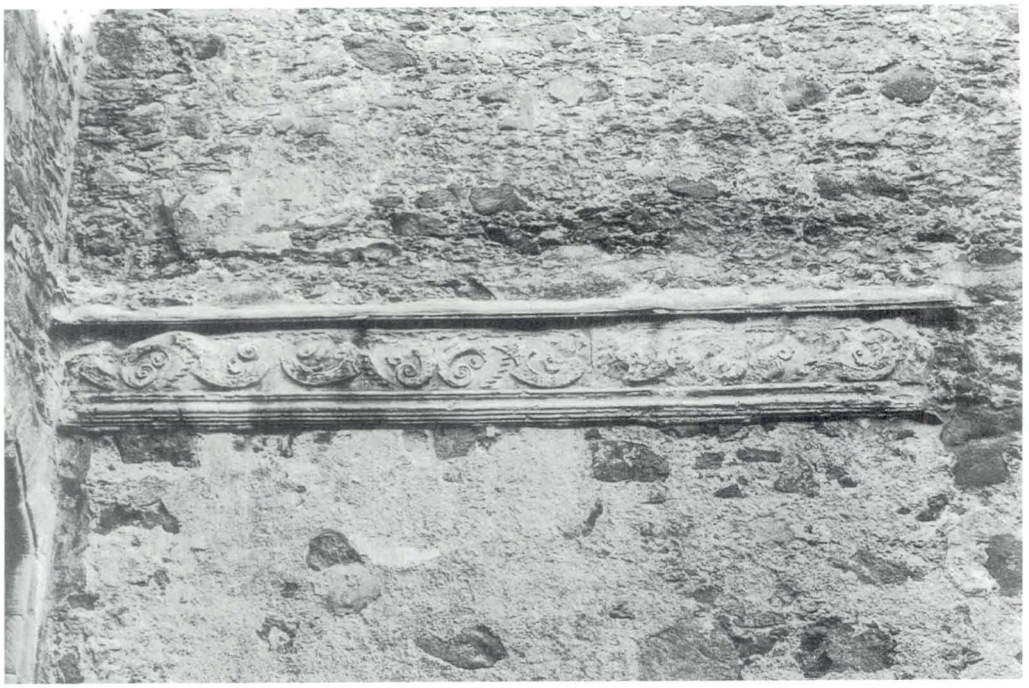
Small repairs may be carried out in situ using layers of paper and glue. Acid free papers should be used and synthetic glues such as PVA should be avoided. By carefully softening with steam, small pieces may be removed for cleaning or for repair on the bench, after first drawing around them to record their position in the design. Ornament which has distorted or fallen away from its background may also be lightly steamed to soften it for gentle re-shaping. Repaired work should be refixed with pins.

3.15 Consolidation of ancient plaster

In general, the conservation of ancient plaster of archaeological importance needs to be carried out by a suitably skilled and experienced conservator, whose aim is to arrest decay with an absolute minimum of disturbance, loss or substitution of original fabric.

Using specialist skills and techniques the conservator works with hand sprays, sponges, small brushes, spatulas and syringes to save and consolidate small sections of plasterwork at a time.

Lichen, moulds and mosses need to be carefully removed by hand from the surface of the plaster to facilitate close inspection and consolidation. Damaged or defective plaster may be fed and strengthened by frequent applications of lime water.



14. Exposed fragments of mid sixteenth century internal plaster at Huntly Castle

Where plaster coats have separated or become detached from the masonry background, the plaster is carefully prepared and voids injected with grout to reinstate adhesion between surfaces. Soft mortar fillets are introduced at the exposed edges of original plaster to combat water penetration. Similarly a sacrificial weather coat of lime plaster may be introduced to protect exposed areas of backing coat.

Plaster ornament and enrichment will often need re-supporting in the course of repair. Grouting, filleting and mechanical fixings are used as a means of securing vulnerable decoration.

Any painted decoration discovered during consolidation should be examined urgently by a suitably skilled and experienced conservator.

3.16 Aftercare and removal of paint

On its own, plasterwork does not require maintenance but, as with all historic interiors, regular inspections are essential to ensure that neither the plaster nor any timber to which it is fixed are affected by dampness, structural movement, fungal or insect attack.

While there is evidence that the finished surface of some early plasterwork was left untreated, it was common to apply a coat of limewash or distemper to the finished plaster to protect against staining and dust. The redecoration of decorative plasterwork with successive layers of paint may eventually obscure detail and affect the character of plaster ornament. It is advisable to give careful consideration to the frequency with which redecoration needs to take place.

Traditional lime plaster, particularly where applied direct to masonry, depends on a high level of porosity to assist the free evaporation of moisture caused by dampness and condensation. For this reason modern paint systems containing synthetic resins such as emulsion or gloss paints (which seal the surface of the plaster and can give rise to staining, disfiguration and flaking) should not be used. Apart from their authentic appearance the traditional permeable finishes of limewash and water-or size-bound distemper are ideal. Distemper has the added advantage of being easily washed off, enabling the build up of layers associated with modern redecoration to be avoided.

Other traditional finishes such as oil-bound distemper and flat-oil paint may be used on lime plaster that is likely to remain reasonably warm and dry with no risk of condensation, i.e. usually on lath rather than on the hard. These coatings are considerably more impervious than limewash or soft distemper and should only be used where they have existed previously and not on new lime plasterwork which has not fully carbonated, a process which may take at least a year. Most modern emulsions are inappropriate in this context although some may be sufficiently permeable: many emulsions will flake rapidly as the plaster attempts to breathe.

All investigation of existing original decoration should be undertaken by a conservator who can carry out careful analysis of the composition and colour of existing layers of paint. Where existing plaster is badly stained or blackened by successive layers of dust and grime, painted decoration may be severely obscured. Proper examination of such plaster is essential before any preparation for redecoration takes place, particularly where the plaster is applied directly to the masonry and could predate the seventeenth century.

The removal of paint without damage to the plaster may be a specialised task for a conservator, since most techniques can cause damage to plaster. Existing paint should not be removed at all without good reason, for example where the paint layers do not form a stable base for redecoration, where original ornament or enrichment has been unacceptably obscured or where a squeeze is required of existing ornament. Some materials such as papier maché and compo which appear superficially to be plaster will suffer irreversibly from the following methods discussed for the removal of paint from plaster.

The removal of paint from plaster may be labour-intensive especially where there is a complex build-up of different treatments. It is essential to identify the type of plaster as well as the type of paint before attempting any removal. If the origin of the paint is known, the manufacturer should be consulted and a small trial area should be cleaned before tackling the whole. Because of the likely lead content in traditional paints and distempers, all *dry* methods of removal (which would produce toxic dust or flakes) should be avoided. Lead-based paints are usually very durable and it is far safer to leave them undisturbed wherever possible. Any exposure to or handling of lead-based materials must be under strictly controlled conditions in accordance with the Health and Safety at Work Act and relevant Regulations, in particular the Control of Lead at Work Regulations and the Approved Code of Practice from the Health and Safety Executive on the Control of Lead at Work under which a risk assessment should be completed before work begins. Waste should be put in bags clearly marked as "Lead Waste - Toxic" and should be passed to the Local Authority for appropriate disposal.

Heat stripping, for example with blowlamps or gas torches, should never be used in historic buildings because of the serious fire risk as well as the risk of lead poisoning. Hot air strippers are not suitable for plasterwork: the use of power tools should be avoided and mechanical or abrasive methods should only be used as a last resort: cleaning with high pressure water is also unsuitable. Proprietary alkaline strippers, alkaline soaps or detergents such as sugar soap, soft soap, soda etc. all leave harmful residues and should be avoided. Water for removing paint should be kept to a minimum; gypsum plaster in particular will be softened by wetting and scrubbing.

Size-bound distemper is soluble and can be easily washed off by hand with hot water and a sponge or soft brush (and using two buckets to ensure that only clean water is applied). Oil-bound distemper is extremely difficult to remove: it should only be tackled by a conservator, by scrubbing with hot water, or careful use of steam.

Limewash should only need to be removed if it is flaking or failing under a thumb-pressure test. Loose particles may simply be brushed off, otherwise it can be removed with warm water containing a little vinegar or lemon juice.

Emulsion paint may be broken down by steam (using a wallpaper stripper with the metal plate removed) particularly if the paint is unstable or applied to a distemper background. Once softened by steam, the paint can be sponged or lightly scraped off, taking care not to damage the surface of the plaster. The application of methylated spirits will assist the steaming process if the emulsion is very stable.

Oil-based paint cannot be removed without the use of chemical strippers which are extremely powerful and should only be used by experienced conservators. Caustic preparations should never be used since they are difficult to neutralise and they damage the plaster by penetration and deposition of a harmful residue of salts which are impossible to remove. A spirit-based agent which penetrates and softens the paint film is more appropriate, but should only be applied where absolutely necessary: the paint is lifted from its background as the solvent evaporates and several applications may be required. Highly flammable solvents should be avoided. All treatments need to be thoroughly rinsed from the plaster immediately after use, with white spirit or water as appropriate. All solvent-based preparations can be extremely harmful to health: they should only be used after an assessment has been carried out under the Control of Substances Hazardous to Health Regulations, identifying precautions and control measures necessary to ensure the safe use of the substances selected. Chemical strippers tend to reduce the adhesion between future layers of paint and the plaster.

APPENDIX A
BIBLIOGRAPHY

'Plaster and Concrete', *Architects Journal*, Renovation Supplement, March 1989.

Apted, M.R., *The Painted Ceilings of Scotland*: 1550 - 1650, 1966.

Ashurst, J. & N., *Practical Building Conservation, Book 3: Mortars, Plasters and Renders*, English Heritage, 1988.

Bankart, George P., *The Art of the Plasterer*, B.T. Batsford, London, 1908.

Bankart, G. P. & Turner, L. A., *'The History and Uses of Plasterwork'*, Journal of the RIBA, 1888 - 89, pp. 132 - 43.

Beard, Geoffrey, *Decorative Plasterwork in Great Britain*, Phaidon, 1975.

Beard, Geoffrey, *Craftsmen and Interior Decoration in England*: 1660-1820. 1981.

Beard, Geoffrey, *'Plasterers in 17th Century Scotland'*, Country Life, 10th April 1969, pp. 909 - 912.

Beard, Geoffrey, *Stucco and Decorative Plasterwork in Europe*, Thames and Hudson Ltd, 1983.

Beard, Geoffrey, *'The Plasterer's Art'*, Traditional Homes, March 1986, pp. 34 - 46.

Bowley, Brian, *'Is Your Ceiling Live?'*, Historic House Magazine, Winter 1991.

British Standards Institution (including European Standards)

BS7913:1998 *Guide to the principles of the conservation of historic buildings.*

DDENV459-1:1995 *Building lime. Definitions, specifications and conformity criteria.*

BS/EN 459-2:1995 *Building lime. Test methods*

BS890:995 *Specification for building limes.* (This will be withdrawn when EN459 is formally incorporated into British Standards)

BS8821992 *Aggregates from natural sources for concrete.*

BS1199/1200:1976 rev 1986 *Building sands from natural sources*

BS8000-10:1995 *Workmanship on building sites.* Code of practice for plastering and rendering.

Bristow, Ian C., *Redecorating Your Church*, Church House Publishing, 1986.

Constantinides, Ian & Young, Rory, *'First Hand Experience with Lime Plastering'*, Period Homes, vol 5, no 10, pp.34 - 35.

Cornforth, John, *'Putting up with Georgian DIY'*, Country Life, 1992.

Davey, Heath, Hodges, Ketchin, Milne, *The Care and Conservation of Georgian Houses,* Butterworth, first published 1978, third edition 1986.

Dunbar, John, *'The Building of Yester House'*, East Lothian Antiquarian Society Transactions, 13 Nov. 1972, pp. 20 - 42.

Drury, P J *'Joseph Rose Senior's Site Workshop at Audley End, Essex: Aspects of the Development of Decorative Plasterwork Technology in Britain during the Eighteenth Century'*, The Antiquaries Journal, vol. 64 part 1, 1984.

Feilden, Bernard M., *Conservation of Historic Buildings*, Butterworth Scientific, 1982.

Fidler, John, *'Plaster Imperfect'*, Traditional Homes, January 1991, pp. 89 - 93.

GIBBONS, P, Scottish Lime Centre Trust, *Preparation and Use of Lime Mortars*, Technical Advice Note 1, Historic Scotland, Edinburgh, Second edition, 2002.

GIBBONS P, NEWSOM S & BROWN S, Scottish Lime Centre Trust, *External Lime Coatings on Traditional Buildings*, Technical Advice Note 15, Historic Scotland, Edinburgh, 2001.

Grandison, L.S., *'Ornamental Plaster Ceilings: Assessment of Condition, Stabilising and Taking In Situ Impressions'*, Peebles, 1988.

ICOMOS, *'The Burra Charter'*, 1981.

ICOMOS, *'The Venice Charter'*, 1964.

Jack, J.F.S *'Notes on the Repair and Preservation of Plaster Ceilings'*, Journal of the RIBA, September 1950, pp. 416 - 19.

Lorimer, R.S., *'Scottish Plasterwork'*, The Builders Journal and Architectural Record, April 7, 1897.

Millar, William, *Plastering, Plain and Decorative*, Batsford, 1897.

Mitchells Building Construction, King, Harold and Everett, Alan, Components and Finishes, B.T.Batsford, 1989 (current editions)

Pegg, B. F. & Stagg, W. D., *Plastering - A Craftsman's Encyclopaedia*, Crosby, Lockwood, Stapels, 1976.

Rossage, M., *'Coping with Cornices'*, Traditional Homes, April 1986, pp. 64-8.

Schofield, Jane, Draft chapter *'Ornamental Plasterwork'* for forthcoming publication *Treasures on Earth,* Donhead Publishing.

Schofield, Jane, *'Real Plasterwork'*, SPAB News vol. 11, no. 3, 1990.

Scottish Conservation Bureau, Historic Scotland, *Scottish Conservation Directory* 1991.

Simons, Paul, *'Repairs to Floor Structures and Plasterwork'*, SPAB News, Volume 1, No. 4, October 1980.

Stagg, W.D & Masters, Ronald, *Decorative Plasterwork - Its Repair and Restoration*, 2nd Edition, Attic Books, 1986.

Touche, John, *'The Worthies and the Regalia'*, National Monuments Record for Scotland Archive.

Turner, Laurence A, *Decorative Plasterwork in Great Britain*, Country Life Publications, 1927.

Verrall. W., *The Modern Plasterer*, 2 vols, Caxton Pub. Co. Ltd. c.1937.

WINGATE, M, *An Introduction to Building Limes*. SPAB Information Sheet No. 9, The Society for the Protection of Ancient Buildings, London, 1990.

Wright, Adela, *Removing Paint from Old Buildings*, Society for the Protection of Ancient Buildings: Information Sheet 5, SPAB, 1986 (second edition 1988, reprinted 1989).

APPENDIX B
USEFUL ADDRESSES

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 for plasterwork and general use of lime materials: -

Scottish Lime Centre Trust, The Schoolhouse, 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: -

The suppliers marked * produce a limited range of materials.

*Cumming & Co, 8 Whitefriars Street, Perth PH1 1PP. Telephone 01738 567899.

*Leonard Grandison & Son, Innerleithen Road, Peebles EH45 8BA. Telephone 01721 720212.)

*Becky 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 & plasters, lime putty, hydraulic limes, limewash, aggregates & 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

*William McVey, Hawkhill Cottage, Stevenston, Ayrshire, KA20 4LF. Telephone 01294 603033.

Specialist analysis of original plaster, and other, materials: -

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

Telephone 01383 872722 *(Mortar characterisation, specialist thin section analysis and simple chemical analysis)*

CMC Ltd, Wallace House, Whitehouse Road, Stirling FK7 7TA. Telephone 01786 434 708. *(Chemical and X-ray analysis)*