The maintenance series

Information sheet

7.1

NSW Heritage Office

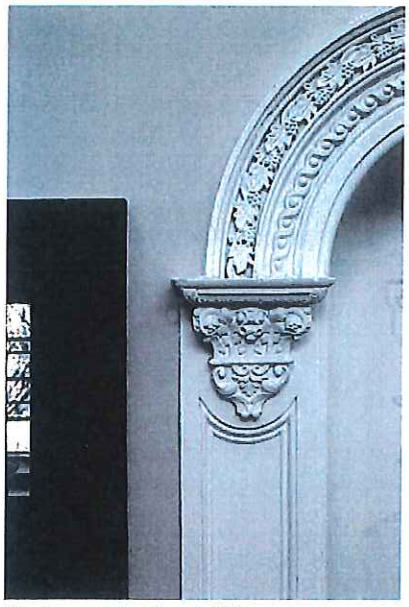
Plaster finishes

Introduction

Plaster is the most common form of surface treatment found in traditional masonry buildings. It was used extensively to achieve a true and even surface finish on all forms of masonry. On timber-framed walls and ceilings it was applied over timber and metal laths. In traditional building practice plaster was also widely used in moulded and cast form for interior and exterior decoration.

The forms and composition of modern plaster elements differ from those of the past. It is therefore important to understand how traditional plasters were made and used to be able to use them and their modern substitutes correctly in building repair and conservation work.

Example of mid-19th century decorative plasterwork incorporating mouldings and cast ornamentation made on site.



Photograph by Donald Ellsmore.

What is plaster?

Confusion surrounding the term 'plaster' arises from the widespread use of the term to describe all forms of surface coatings applied by 'plasterers', including fibrous plaster and plasterboard, which are precast. Unless otherwise indicated below, *plaster* means an internal or external application of solid material comprising sand, lime and various additives, applied wet in one or more coats to produce a smooth, hard surface finish. *Render* is used to describe the first of the traditional three coats internally, and also to mean coarse, single-coat, external work.

Lime and naturally occurring cements have been in use since Roman times. Early colonial builders obtained a crude form of building lime by heating sea shells in open fires or kilns to produce the calcium oxide, or quicklime, which is the chief element in lime mortars and plasters.

Internal plasters and external renders

Traditional plasters and renders include a wide range of aggregates, binders and reinforcement. Colonial builders relied on the use of sand (or loam), lime (originally obtained by burning sea shells) and hair (cow hair or another chopped fibre) for interior and exterior plasters and renders. Hydraulic limes and cements were introduced, as they became available, to add strength and hasten setting times. Since the 1870s plasters have commonly incorporated Portland cement (for strength) and gypsum, or plaster of Paris (for rapid hardening and smooth finishing).

Colonial builders did not always have access to the best plastering materials. Substantial quantities of clay, loam, shell, straw and other so-called impurities were incorporated into early Australian plaster mixes. Recent research tends to indicate that the presence of such impurities sometimes enhanced the quality of these plasters, and many are still strong and durable today.

Lime and cement

Lime and naturally occurring cements have been in use since Roman times. Early colonial builders obtained a crude form of building lime by heating sea shells in open fires or kilns to produce the calcium oxide, or quicklime, which is the chief element in lime mortars and plasters. Later, natural chalk and limestone were quarried for calcium carbonate, which was burnt (calcined) in kilns to obtain quicklime. 'Lime putty' was then obtained by slaking the quicklime (combining it with water) and allowing it to stand in pits or barrels for about 14 days to achieve the creamy smooth consistency needed for plastering.

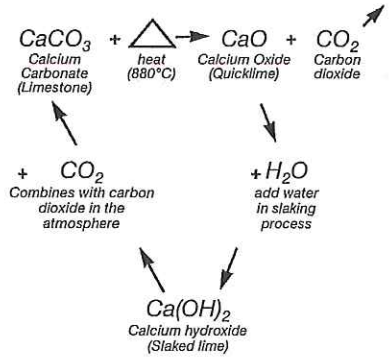
This was and still is a tricky process. Quicklime (unslaked lime) is unstable and must be kept dry and used fresh. The reaction of lumps of quicklime with water produces great heat, known as the boiling of the lime. Unless the 'boiling' process is completed, even very small chunks of unslaked lime will disrupt the surface of a finished plaster when they combine with moisture in the air. Lumps of rock lime thus need to be fully broken up, and the resulting putty carefully sifted before use.

Slaked lime (calcium hydroxide) sets by combining with free carbon dioxide in the atmosphere to form calcium carbonate again. The setting process is slow, which significantly delays the application of other surface finishes such as paint.

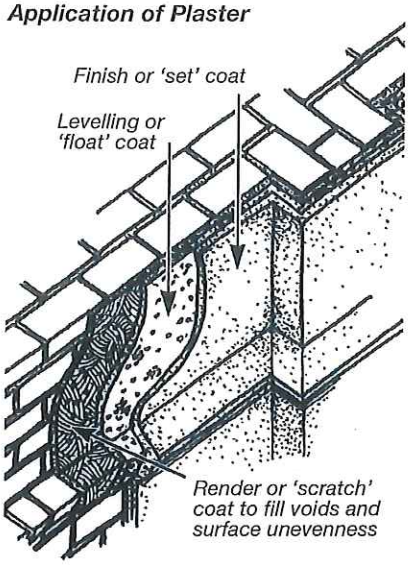
Hydraulic limes and cements were introduced because of their capacity to harden by chemical reaction with water and thus reduce the setting time for plaster. Naturally occurring hydraulic limes (from limestone containing impurities such as clay) imparted particular setting characteristics when calcined in the same manner as quicklime.
It was discovered in Europe that combinations of lime and some volcanic earths could produce materials such as 'Roman' cement, which were the precursors of modern-day cements. Portland cement, first manufactured commercially in Australia around 1870, soon became an important element in plaster mixes and mortars.

The Lime Cycle

The cycle of burning, slaking and hardening of common building lime.



Application of Plaster



Application of traditional plaster in three coats.

Illustration by Donald Ellsmore.

Plasters

Gypsum, a form of calcium sulphate, was the main component of plaster of Paris, the principal material for decorative plasterwork. Gypsum and plaster of Paris can be readily combined with lime and sand to produce mixes which set rapidly with a hard finish. Gypsum plasters are inappropriate for coarse work or renders because their working time is limited. However, they are most suitable for finishing and patching.

Gypsum is also the principal material in various modern forms of plaster, including plasterboards. Fibrous plaster sheet linings and decorative devices, introduced around 1910, are cast in plaster of Paris with sisal fibre reinforcing. Fibrous plaster superseded solid plaster in many classes of work, especially in timber-framed construction.
Although fibrous plaster sheeting has now been superseded by paper-faced plasterboard sheeting, it continues to be used for decorative devices such as ceiling roses and cornices.

How is plaster applied?

Plaster is applied with a trowel in three or more coats according to traditional practice. The first coat (called the render, scratch coat or coarse stuff) is designed to fill voids and even the surface. The next coat of similar but finer material is referred to as the levelling or float, as it is finished with a wooden float ready to accept a finish of fine stuff. Finishing coats of lime and plaster of Paris (called setting stuff or fine stuff) are applied with a steel trowel and can be worked up to a very smooth and glassy finish.

Coarse stuff was traditionally reinforced with animal hair or chopped grass. Its proportions are three parts aggregate (sand) to one part of binder (lime and reinforcing material, often with cement added). The first coat is roughly trowelled on and its surface is scored to provide a key to accept the next coat.

The floating coat may contain a higher proportion of sand aggregate than the render and a small proportion of fine reinforcing material such as animal hair. It is ruled off with a long, true levelling batten to set up a perfectly regular finish to receive the finishing coat.

Finish coats are finer again, and contain lime and a small amount of very fine sand, a little gypsum to overcome crazing during the setting of the lime and often a pigment for integral colour. Keene's cement, a modified form of plaster of Paris, was used in high quality work to create a rich, coloured finish. Other modified, hard plasters were used in high-wear areas such as hallways to provide a durable, impact- and abrasion-resistant surface. Generally, it is better not to apply a coat of render to a background weaker than the following render coat.

Special decorative forms of plasterwork used in high quality work, such as Scagliola (which imitates marble or other coloured stone) have particular conservation requirements beyond the scope of normal plastering practice.

Run Moulding

Run mouldings are developed with the aid of a plasterer's horse.

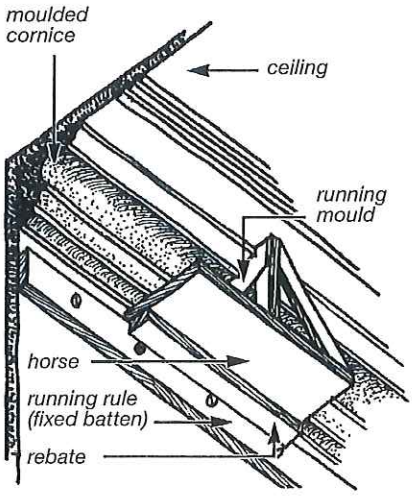


Illustration by Donald Ellsmore

Table of typical plaster mixes for traditional work

INTERIOR PLASTER		Gypsum	Lime	Sand
Traditional mix	Scratch	–	1 [putty]	3 [reinforced with fibre]
	Float	–	1 [putty]	3 [reinforced with fibre]
	Set	–	1 [putty]	2
Gauged mix	Scratch	1	1	6
	Float	1	1	6
	Set	1	1	– [thin mix]
EXTERNAL RENDER		**Gypsum**	**Lime**	**Sand**
Traditional (compo) mix	Render	1	1 [putty]	5
	Float	1	1 [putty]	6
	Finish	1	2 [putty]	9
Common (compo) mix	Render	1	2	9
	Float	1	2	9
	Finish	1	3	12

Plaster mouldings

Decorative features are either built up in coats or fabricated off site and fixed in position with plasterer's materials. Plaster ornaments such as modillions and capitals are made in reinforced materials.

Cornices and straight mouldings are made by passing a profile across the wet plaster as illustrated. In such work a running batten is set up on a true line to guide the profile, which is fixed to a plasterer's horse. Large run mouldings are reinforced.

How do traditional plasters differ from those available today?

Traditional lime-based plasters take a long time to set and cannot be painted or decorated with wallpaper until thoroughly dry. Cements and gypsum were introduced in combination with lime to overcome some of these shortcomings.

In contrast, modern materials based on cements and gypsum are modified with various additives to slow down the setting times and make them more workable. They are brittle and unyielding in the solid state and are thus prone to cracking in old buildings subject to movement. They can also impede the natural evaporation of moisture from damp masonry and concentrate moisture or salts, resulting in the deterioration of surface finishes.

Traditional lime-based plasters take a long time to set and cannot be painted or decorated with wallpaper until thoroughly dry.

Great care must be exercised in the use of cement-based mixes. Portland cement-based plasters and repair mixes shrink upon drying as their volume decreases with the loss of water. When dry they are much stronger than traditional lime-based plasters and their use in repair work can lead to mechanical failures in the adjacent materials. Additionally, the movement of expansive salts in the vicinity of cement-based repairs can result in damage to the weaker material.

Lime and gypsum are compatible, as are lime and cement. Indeed, the addition of cement to lime has been common for over a century in Australian building practice. Cement and gypsum cannot be combined satisfactorily.

Analysing plasters

Laboratory analysis can be undertaken to determine the exact composition and strength of plaster, but is rarely necessary in order to decide on appropriate conservation treatments. An experienced person can readily distinguish the type of plaster by visual observation sufficient to specify a conservation treatment. Cement-based plasters have distinctive colours.

A common structural failure occurs at wall junctions, resulting in moisture and salt damage in the plaster and applied finishes.

Photograph by David Ellsmore.

Early plasters with substantial fibre reinforcement are normally sound enough to be refixed by screwing or gluing. Late 19th- and early 20th-century lime plasters, usually unreinforced, can be very fragile and unsuited to such repair methods. Cement-based plasters will often be sound in themselves but detached (drummy), or even creating damage due to their hardness and superior strength. These might need to be removed as part of a treatment. It is always essential to check an apparently sound external plaster by tapping it extensively to identify any drumminess.

Why does plaster fail?

The most common forms of failure are physical damage and moisture damage.

Lime-based plaster, although solid, retains some flexibility if reinforced. It can thus accommodate limited structural movement in substrates. Such plaster surfaces cannot, however, withstand impact from hard or sharp objects. Timber impact strips in the form of skirtings and chair rails were provided to prevent damage from furniture. Timber dowels (staff moulds) provided similar protection on external corners. Impact damage to plasterwork is usually found in high-wear areas such as hallways.

Moisture causes plaster to swell and shrink as the humidity of the air changes, which can be enough to create drumminess or cracking. Moisture can have the same effect on timber laths supporting plaster, or on fibrous material in a primitive plaster mix. However, the most common moisture damage to plaster is that caused by migrating salts carried to the plaster in solution from damp masonry. Many soluble salts can cause severe surface disruption as they crystallize and expand.

Lath-and-plaster ceilings can fail; laths from the ceiling detach from the joists due to corroded nails, or by breaking of the keys, which allows the plaster to come away from the laths. In either case the weight of the plaster will eventually cause it to fall.

Plaster is very vulnerable during renovation work due to the normal vibrations associated with such work. It is important to take all necessary precautions to secure loose or damaged plaster, since it cannot be reinstated once it detaches completely.

Failure of lath-and-plaster ceiling

The most common forms of failure of lath-and-plaster ceilings.

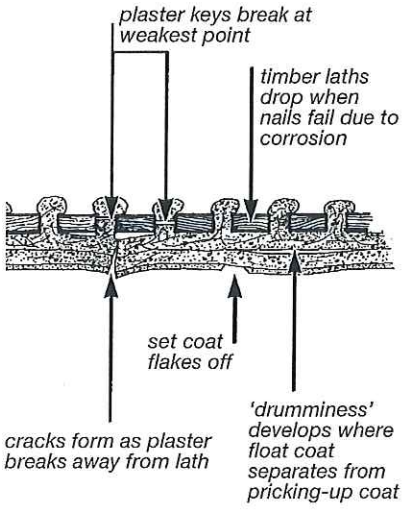


Illustration by Donald Ellsmore.

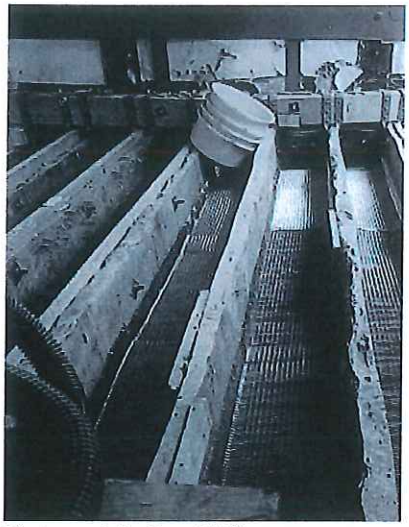
Plaster repair methods

The principal aim of all types of repair should be to retain and consolidate as much original material as possible and to minimize the amount of introduced material.

Plaster with areas of surface damage from impact or abrasion can be filled and repaired with traditional plaster mixes and some other compatible materials. Plaster which is sound of itself but detached or becoming detached (drummy) can be reattached by chemical adhesion or by screwing it back to the substrate.

The consolidation and reattachment of lath and plaster traditionally involved the use of wire ties, screws and washers. It is difficult, however, to both support a weak ceiling and repair it from below. Modern acrylic resins are often used today.

The top side of the lath and plater ceiling is thoroughly vacuumed and wire mesh is fixed to the ceiling rafters to receive a new layer of plaster.



Photograph by Donald Ellsmore.

Another method of repair for lath-and-plaster ceilings is the application of a new coat of plaster on top of the old. The disadvantage with this method is that it requires its own support to avoid overloading the already heavy plaster. For the method to be successful, the new plaster must form a good bond with the old. To achieve this it is often necessary to deal with the accumulated hydrophobic dirt and dust by thoroughly cleaning the top surface of the plaster and laths.

Readhesion methods

When otherwise sound plaster is falling away from walls and ceilings, it can be readhered with compatible adhesives which must be resistant to hydrolysis, oxidation and microbiological attack. Adhesives based on starch, casein and PVA do not satisfy these criteria. Certain acrylic-resin-based adhesives, developed for use as cement additives and available under trade names such as Rhoplex, Primal and Westox RAP, are very well suited for most plaster repairs provided they are properly applied.

A pre-wetting mix of adhesive thinned with water and alcohol is designed to soak into porous plaster to consolidate any friable or cracked material. This mix will run into voids and will even attach plaster to the laths. It is ideally suited for flooding onto the cleaned top side of a damaged ceiling.

An acrylic adhesive, or a filled and thickened mixture of such adhesive, can be injected into voids to bridge even the most substantial gaps behind drummy plaster. These can be used in combination with the pre-wetting mix or primer to consolidate unsound plaster. A caulking gun or large syringe is used to inject the material through small surface holes or existing cracks to reach voids beyond. The method is both cost effective and conservative, aimed at preserving historic fabric intact, rather than removing and replacing large areas of plaster. It can be used in conjunction with traditional methods.

Repair of Lath-and-Plaster Ceiling

Repair of lath-and-plaster ceiling by chemical readhesion: the plaster is supported from beneath with props and padding while acrylic-resin-based adhesive mixtures are flooded onto the cleaned surface or injected through laths.

Illustration by Donald Ellsmore.

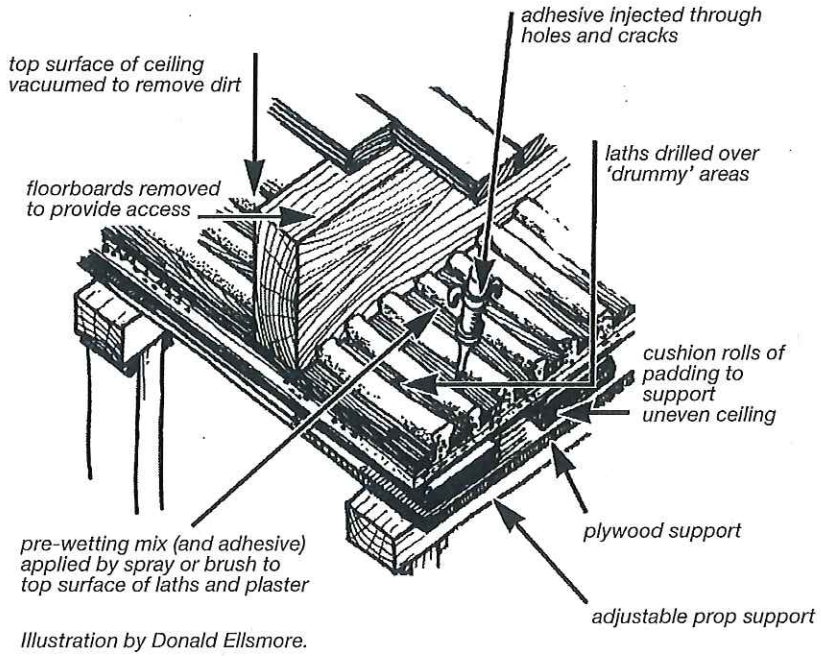


Illustration by Donald Ellsmore.

The big disadvantage in using acrylic-resin-based adhesives is soiling. When thin materials are being flooded onto ceilings or injected into voids, there is a high potential for the materials to migrate into areas where they can harden and damage decorative finishes. The injected material can also force loose plaster away from the substrate. Although the acrylic-resin-based adhesives can be cleaned up with soap and water when still wet, they must be dissolved in a solvent such as alcohol once they have set. These drawbacks can be avoided with good site practice, and it is thus essential to select the contractor with care.

Upgrading fire resistance of plaster

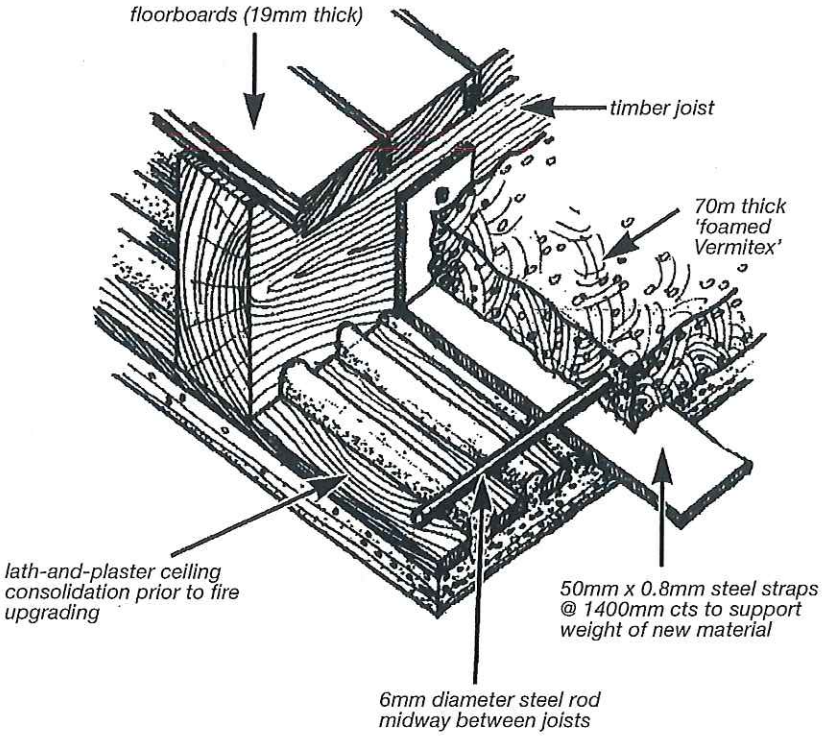
The requirement to upgrade old plaster ceilings and walls to meet standards for fire rating may not require the destruction of original fabric. Recent tests confirm that traditional lath-and-plaster ceilings in sound condition can provide an acceptable level of fire safety when appropriate fire safety systems, such as early warning systems, are in place. Unsound ceilings can be brought up to an acceptable standard using the repair and consolidation methods described above.

The fire rating of a lath-and-plaster ceiling can also be upgraded to a level of 60 minutes by the introduction of reinforced, foamed vermiculite. Further details regarding this method are provided in a technical information sheet produced by the NSW Heritage Office.

Upgrading plaster ceiling

Upgrading a plaster ceiling: application of "foamed Vermitex" to give fire resistance level of 60 minutes.

Illustration by Donald Ellsmore.



General principles

The study of historic building fabric is essential to a full understanding of the significance of traditional architecture. It is therefore important to preserve plasterwork in situ. Modern methods are quite different from traditional methods. New material, even reconstructed plasterwork, does not have the same characteristics as the old. The best approach is to aim for the preservation of existing historic material and to undertake repair work in traditional and compatible materials. The use of acrylic-resin-based repair methods is recommended to aid in the retention of existing building fabric.

The NSW Heritage Office publishes a directory of suppliers and services on its website which includes qualified tradespersons who can advise on traditional plasterwork and conservation repair techniques.

FURTHER READING

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