



FINISHES & INTERIORS SECTOR

BEST PRACTICE GUIDE REPAIR OF HISTORIC CEILINGS



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BEST PRACTICE GUIDE

REPAIR OF HISTORIC CEILINGS

FIS would like to thank the author Sarah Mayfield Msc and all the members of the FIS Heritage Plaster group and the wider heritage community for their work to produce this guide.

The information contained in this guide is based on our understanding at the time of publication. Additional legislation or clarification from government may warrant updates to this paper as such information becomes available.

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Foreword



The conservation of historic ceilings presents a huge challenge, one that demands both sensitivity to our historic environment while also leaving a safe and secure ceiling for future generations to enjoy.

Increasingly, specialist plaster companies are asked to extend the life of fragile lath and plaster ceilings due to interventions of external forces such as water damage, structural alterations or poor maintenance.

With the risk to life associated with extremely heavy lath and plaster ceilings, often located a great height and effectively weighing as much as elevated 'paving slabs', I am delighted that the members of the FIS Heritage and Fibrous Plastering Working Group have pooled their wealth of knowledge and experience to produce this guide, illustrating the pros and cons of the many repair solutions available.

This guide is aimed at building owners and professionals, and contains information on a number of repair options available. Repair and maintenance to historic ceilings must always be carefully considered with three principal skillsets: conservational, structural and plaster practitioner competency.

JONATHAN RILEY
CHAIR, FIS HERITAGE AND FIBROUS PLASTERING
WORKING GROUP

FIS is the trade body representing manufacturers, suppliers and installers in the fit-out sector, including heritage and fibrous plastering. The Heritage and Fibrous Plastering Working Group is an inclusive body with the following objectives:

- Develop technical standards as required
- Promote best practice in the market

- Educate and inform clients and specifiers about (working group) work
- Promote the products and skills of FIS members in this field
- Monitor and support risk on behalf of the community
- Shape the market so that the correct adherence to standards is recognised and adhered to by all, to the benefit of clients.

Foreword



Historic ceilings of lath and plaster vary from the highly decorative to the plain, with even the latter contributing to the historic aesthetic of a room, with undulations and cracks giving an authentic character. Furthermore, any ceiling may have concealed, overpainted decoration with increases in its significance. And all contain layers of paint stratigraphy that capture the chromatic history of the room; this can be studied to inform historic redecoration schemes.

In listed buildings, such ceilings fall within statutory protection so are subject to controls for their repair. However, listed and unlisted ceilings requiring repair can be at risk from faulty specifications or workmanship. Certain stabilisation techniques are better than others at reducing the impact of the repair on the authenticity of the ceiling.

Where there is a severe risk of collapse, with loss of human life or property, repair techniques need to be assessed for their provision of security. They should also be proportionate in cost to the significance of the ceiling.

This guide provides a description and assessment of the range of repair techniques within the context of adequately understanding historic buildings. The aim is to enable a level understanding of the technical issues in the decision-making process among stakeholders, be they building owners or managers, architects or surveyors, plaster contractors or conservation officers. This better understanding will hopefully raise the standard of repairs, so that the significance and authenticity of the ceiling can be assured.

JOHN STEWART

HERITAGE BUILDINGS EXPERT

CO-EDITOR OF 'MORTARS, RENDERS & PLASTERS' (2012)
ENGLISH HERITAGE PRACTICAL BUILDING CONSERVATION SERIES

“The most successful historic building projects are when the client, craftspeople, professionals and local authorities work together to compare experiences and arrive at decisions.”

Introduction

This guide has been written by representatives of the plastering trade and building conservation to provide the historic building trades and professions a reference to the conservation of historic plaster ceilings grounded in good conservation principles. The methods described were peer reviewed and endorsed by trade and professional bodies alike.

When dealing with the wealth of UK historic buildings there are nearly always surprises and no one person can hold all the experience or eventualities. The most successful historic building projects are when the client, craftspeople, professionals and local authorities all work together to draw on their expertise to arrive at decisions. Each ceiling needs to be assessed according to its historic value. This guidance document aims to facilitate these discussions and specifications by looking at the advantages and disadvantages of each treatment method in consideration with the heritage value of the ceiling and the conservation implications of the method.

The most common type of historic ceilings in the UK are constructed of timber laths and three coat lime plaster, this guidance focuses on the support of these traditional ceilings. Particular exceptions and other materials are discussed. Most historic ceilings have a heritage value, from low to very high. This value needs to be considered when deciding on the appropriate treatment and is discussed further in the section 'Assessment'.

Surveys and diagnosis need to be undertaken by a competent plaster inspector who will be aware of possible variations in materials, structure and application. The plaster inspector may need to liaise with a conservator, structural engineer or other specialist as the issues contributing to a

plaster failure become clear. This book will guide the reader through understanding the methods and good practice required by anyone involved in repair and the care of older ceilings.

Unless the practitioner can demonstrate competence to inspect and carry out interventions to repair an historic ceiling a professional and competent conservator should be consulted before carrying out any work.



Figure 1: a traditional lath and lime Elizabethan ceiling during restoration.

Principals of building conservation

Today, a leading principle of building conservation in the UK is to maintain the heritage value of various components, such as ceilings and their context. This is based on an understanding of historical significance, defined for heritage policy as:

“The value of a heritage asset to this and future generations is because of its heritage interest. The interest may be archaeological, architectural, artistic or historic. Significance derives not only from a heritage asset’s physical presence, but also from its setting.”

National Planning Policy Framework 2012

Other principles that support this include:

- Retention of as much historic material during repairs
- Use of reversible materials when possible
- Minimum intervention and minimum interference with the historic fabric so that there may be an opportunity for the ceiling to be re-treated in the future.

These principles are applied within a conservation process that requires:

- Understanding of the history of the building and its materials
- Assessment of significance, condition and risks
- Appraisal of repair options and recommending the most suitable ones
- Repair with appropriate materials and techniques
- Maintenance and monitoring.

In some historic buildings, there may be conservation management plans in place with defined policies and principles. In others, it is the responsibility of the owner, craftspeople and other conservation professionals to ensure that a robust conservation process is followed for a specific project.

Understanding the history of the ceiling and its materials

BUILDING USE AND EVOLUTION

Past and present uses of the building along with earlier repairs and adaptations will influence the behaviour of a ceiling and needs to be understood as a whole by any experienced inspector or specifier to read symptoms of failure.

Over time, changes in use of a building with significant alterations may have altered the structural dynamic of its ceilings for example notching of joists for installation of electrical or plumbing services; extreme changes in weight loading such as filing cabinets or mainframe computers; removal of walls or adding doors over time.

CONSTRUCTION OF A TRADITIONAL LIME PLASTER CEILING

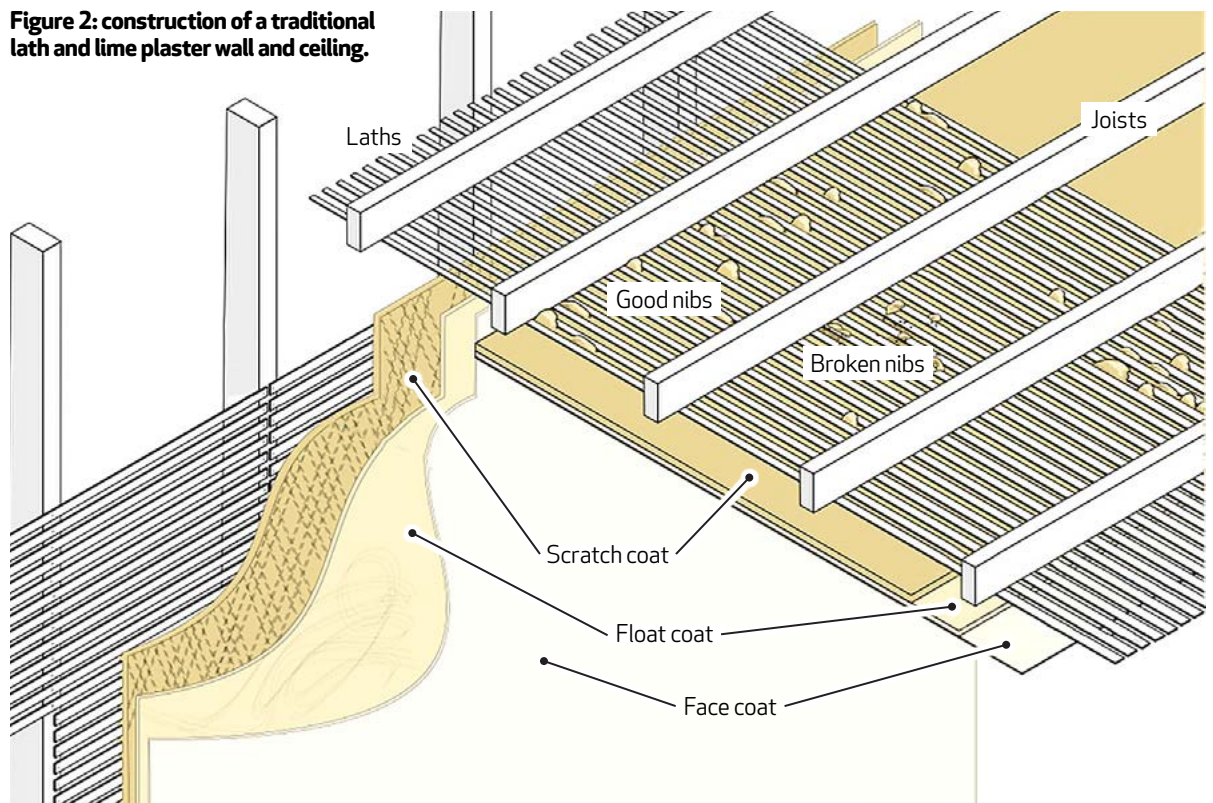
The most common arrangement for a traditional ceiling is constructed by nailing riven timber laths up to timber ceiling joists. Laths, thin lengths of oak, chestnut or pine, were riven by splitting a timber log along the

grain. In the Midlands and East of England reeds are often used instead, secured with a lath along the joist to hold them in place (see figure 3). Laths require a small finger (approximately 10mm) space between each to allow the first coat of plaster applied to squeeze up between the laths and form nibs (or keys, lugs, snots or hooks), the mechanical fixing of the ceiling to the structure.



Figure 3: example boards showing earth mortars on reed (left) and lime plaster on laths (right) (Sean Wheatley).

Figure 2: construction of a traditional lath and lime plaster wall and ceiling.



Understanding the history of the ceiling and its materials

Materials tended to be vernacular (locally sourced) prior to nationwide and international distribution enabled by the railway network, so the materials used for a ceiling were chosen by the immediate resources around the site. A variation of this can be where ceilings were thin or may have used more earth mortars for the backgrounds and reserved any lime to finish a smooth face coat (also known as setting or topcoat). Where there was a scarcity of lime shells were often used.



Figure 4: exposed ceiling void showing a good selection of nibs formed between laths.

Limestone was burnt to form quicklime. Quicklime is very reactive with moisture and unstable so would have been mixed with sand and water and used quite soon after (hot-mixed lime) or covered in water to slake for months or years (lime putty). Either way the lime was mixed into a mortar with sands and animal hair mixed in. Once hot lime was prepared it was used almost immediately, or within a week and kept airtight. Once applied, lime doesn't 'set' as it dries, it carbonates, strengthening as it draws in carbon dioxide from the air, so it needs a few days between coats to absorb and gain strength.

Lime plaster mixes can vary hugely, the most typical ratio 1:2.5 quicklime to aggregate used for the scratch and float coats. Hair was mixed in shortly before use

to avoid the lime dissolving the protein in the hair and weakening the strands. The hair was from any animal with suitable hair that was abundant. Usually horse, cow or goat. It was the last ingredient to be added prior to application as the lime would degrade the hair if left mixed for a week or more. The hair was teased in by hand from a bundle to achieve an even distribution. Once lifted on a trowel the plaster would show an even consistency of hair with a light 'beard' over the edge of the trowel. Polymer hairs are common in modern lime plaster as they can be premixed without risk of degrading, these do however introduce a plastic unnecessarily into the environment when natural hair has proved sufficient for centuries.

Typically, the bed of laths of a traditional ceiling would have various undulations so the first coat of plaster (also known as backing, pricking up, or scratch coat) would be applied to create the background (see figures 2 and 3). This coat would be spread across the laths, adhering to and pressing up through the gaps and forming the curling nibs (key) that, once set, mechanically tie the plasterwork to the structure. This coat was then scratched with a splay of pointed laths to key the surface so that the next coat can lock into the face of the first. Once the plaster has carbonated and hardened enough (4-14 days, or even longer depending on environmental conditions, at the discretion of an experienced plasterer) the second coat, or float coat, made of the same mortar mix as the scratch coat, is applied to a smoother surface than the first. This float coat is finely scratched with a large comb or devil float ready for the last layer. Another two to five days later the final face coat, or topcoat, of a finer 1:1 lime to a grained fine light sand is applied and troweled to a fine, smooth face.

Understanding the history of the ceiling and its materials

HISTORIC MATERIALS AND THEIR IDENTIFICATION

Until the early 20th century, there was a relatively limited range of materials used for ceiling construction. These are described below. The nature of materials and applied decoration reflected the status of the building and its owners. In higher status buildings, a variety of different materials may have been used.

Traditional haired lime plaster laid onto timber laths in three coats is the most common application found in historic ceilings, it varies little in general material and application from the early 18th century right up to the First World War.

When working with an historic ceiling other materials can often only be revealed once works are underway. Repair works may have been specified, tendered and awarded yet other historic materials are often only apparent once the craftsman begins, who needs to be aware of other materials so as to reassess, adapt their method and not cause damage. Later repairs can damage or stress the original materials or, if stable, add to the story of the ceiling - both need to be judged and balanced.

Early lime plaster

Early Elizabethan lime plaster ceilings vary enormously depending on region and their influence from the London guilds. They tend to be thinner than Georgian and Victorian ceilings with a higher ratio of hair and lime. This can result in ceilings that are bound together well and remain attached whilst missing many nibs as they can behave like a thick sheet of fabric. The Plaisterers Livery achieved royal charter in 1501. The guilds of the City of London had a very strict system that only the best plasterers could join. The best skills centred on the capital and the Royal palaces yet higher status clients



Figure 5: Georgian haired lime plaster (right), 20th century lime gauged with gypsum (left).

employed these plasterers further afield for their country estates and demonstrated their elaborate ribs and strap work style, which was in turn, copied by regional crafts people.

Earth plasters

The earliest plaster (plaster meaning as a verb 'to spread') was daub, using the very immediate mud or clay around the site. The better mixes are the ones that survive today, often using a mix or variation of clay soil, cow dung, chalk, sand and straw. In some regions earth mortars were so successful that they remained the dominant material with lime being reserved for the smoother topcoat.

Timber buildings filled their frames with timber staves and woven hazel twigs to make a wattle screen that once plastered formed wattle and daub walls. Daub, as with all plasters, could be applied direct to masonry walls. Historic earth mortars can include lime content but tend to reserve lime for the topcoat to achieve a more durable and finer finish.

Earthen mortars, laid on laths, a natural progression from wattle and daub, continued in rural areas well into the Victorian period and are enjoying a modern revival as a sustainable, low transport, low carbon alternative.

Understanding the history of the ceiling and its materials

Lime plaster late 19th to the early 20th century

Lime plaster from around the time of World War One tends to be more brittle as it is often heavily gauged with gypsum to bring on the set of the lime faster making a more brittle product than traditional work. Hair is present yet tends to be shorter and in much less quantity than traditional work meaning it does not have the same binding matrix, so the already brittle plaster nibs break more easily and cracks are more likely to release areas of plaster than with traditional plaster.

Freehand modelling

Lime plaster could be built up to create free flowing forms often drawn from nature or myth and frequently sourced from pattern books from the Netherlands and the further continent. Large ornament could be built up on supports of timber or iron whilst the plaster gains its strength. Elizabethan ornament typically was formed of strap work or interlocking rib designs formed relatively freehand with a timber profile, press moulds and freehand modelling - giving the whole design a softly undulating organic feel.

The late 18th century's large scale supply of gypsum from Montmartre (plaster of Paris) enabled an efficient method of casting repeat ornament so designs moved away from the time-consuming freehand method to elaborate repeat patterns including undercuts in the mould that create shadow and more interest. Unlike lime, gypsum plaster sets in the presence of water without shrinkage offering a faster and more durable method of producing ornamental casts.

Press moulding

Early repeat patterns were formed by pressing lime mortars into moulds. This method required the details to have no undercut and was a delicate process with a high percentage of shrinkage and cracking that had to be managed. Moulds were often timber, carved in negative by

“By the end of the 19th century, manufacturers were devising more reliable and quicker ornament production processes.”

a carpenter so were costly and reused. Other rigid materials were used for moulds such as gypsum or iron. Rigid moulds with lime worked well for small repeated patterns. The mould would first be dusted then a fine lime mix would be worked into the form then the mould pressed into location. These fine mixed ornaments, with little to no aggregate within, would shrink and crack so were soon painted with lime wash to fill cracking and provide a smooth surface then any details touched up by hand.

Gelatine as a mould material provides a certain amount of flexibility but degrades over repeated use and requires a rigid positive for regular re-making of the mould.

Cast plaster

Before the 19th century, supplies of gypsum were more scarce so the material tended to be reserved for casting larger repeat ornament such as corbels, modillion blocks or denticulation, it was also used as an additive to lime casts to hasten set and reduce shrinkage.

Once gypsum became more available, it was more cost effective and reliable to swiftly cast many repeat ornaments and fit them more easily compared to lime. Gypsum plaster could also be used to form multi-piece moulds for casting ornament with undercuts such as curling leaves.

Understanding the history of the ceiling and its materials

OTHER CEILING MATERIALS

By the end of the 19th century, manufacturers were devising more reliable and quicker ornament production processes.

Repaired or past replacement of areas or features can be found in any material such as casts in Roman cement or resins or flat work in expanded metal lath or plasterboard. All need to be recognised to make informed choices about significance of materials, their treatment and influence they may have on original fabric (see figure 7).

Fibrous plaster

This material is prefabricated in a workshop in large, light, thin panels by laminating gypsum reinforced with jute scrim laths and timbers into reverse moulds. The sections are hung to the timber or steel structure with wad ropes made of the same scrim and gypsum, sometimes including wire ties within. In some cases, the panels are fixed to the joists using nails or screws.

Fibrous plaster was introduced from France and patented in 1856 providing the manufacture and fit of whole ornamented ceilings in a fraction of the time and cost compared to traditional plasterwork so soon became the preferred method of ornamenting large spaces.

This hanging system relies on the whole being rigid in contrast to traditional ceilings that can absorb minor shifts in building movement and vibration. Fibrous plaster relies on the integrity of the organic jute fibres that make up the scrim. The hessian scrim can degrade under certain conditions putting stress on hanging points (wads) if they don't contain wire, so some historic examples can be more vulnerable and shorter lived than traditional lime plasters. Older fibrous plaster must be looked after properly and monitored. Modern fibrous plaster can include glass fibre making

it less vulnerable to environmental degradation and all wads should contain wire as a mechanical tie.



Figure 6: detailed composition ornament obscured under generations of paint from an external pilaster.

Papier-mâché

This material was used in Europe for elaborate ornamental objects and even furniture and was adopted in the British Isles in the 18th century to produce ceiling ornament such as roses and garlands. It was made from a combination of animal glue and paper pressed into moulds that were either carved timber or metal. The moulds were often squeezed in a press to compress the cast then the cast was left in a drying room or cabinet to avoid warping. Two piece, male and female moulds were used for compression of precise components or large sheets.

Carton Pierre

A similar process to papier-mâché yet the paper made from rags was boiled down to a pulp, mixed with glue, whiting (chalk dust), rye flour and other company specific ingredients then pressed into moulds. Carton Pierre was often manufactured and fitted in the UK by companies from France.

Understanding the history of the ceiling and its materials

Composition

Also known as compo, was primarily used for the fine details of picture frames. In high status Georgian homes material began to be used for ornament such as decorative door architraves and occasionally low relief ceiling and wall ornament (see figure 6).

The exact composition recipe was company specific yet generally it was linseed oil, animal glue, rosin (tree sap) and whiting. When the ingredients are combined and boiled, they form a very pliable putty that is pressed into hard moulds and can be reheated to fit a frame or to add form to foliage, for example. Composition is more commonly used for small scale ornament on furniture, picture frames or on architraves and dado rails. It has been found as a low relief ornament on ceilings of the late 18th century. Compo is frequently mistaken for carved timber and dissolved in chemical paint strippers. Figure 6 shows composition from an external porch pilaster almost entirely obscured by paint. This was manually cleaned by a conservator with a scalpel blade, this area approximately 100mm² took approximately two hours.

Expanded metal lath (EML)

Also known as EML or ex-met, this mesh became popular in the late 19th century as a quick and cheap way to secure large flat expanses without nailing individual timber laths providing an instant stable grid that can be plastered onto. Sheet metal was perforated with slits - some forms of EML were pressed to undulate the sheet to allow the slits to open for the lime to attach. Other EML designs stretched the slotted sheet to form a lattice as is done today. Historic examples are in ferrous steel and liable to rust.

“Compo is frequently mistaken for carved timber and dissolved in chemical paint strippers.”

Assessment

ASSESSING HISTORY AND SIGNIFICANCE

Any historic plaster ceiling and indeed any historic building can be a heritage asset, whether listed or not. It is likely that all historic buildings will have some significance and this needs to be understood and used to inform proposals for repair, restoration and adaptation in line with relevant guidance and with the use of appropriate expertise, such as an architectural historian and or the local planning authority conservation officer.

Various guidance exists on assessing heritage value historicengland.org.uk/advice/constructive-conservation/conservation-principles/

Plaster does not need to be ornamental to add to the interest of a building. Even very simple historic plasters in vernacular and low status buildings can contribute significantly to the authenticity of a historic interior, for example, through undulating surfaces and accretions of paint layers.

In some instances, the surveyor may identify the need to commission architectural paint analysis where concealed decorative schemes are known, or suspected, to exist. Similarly, material analysis of plaster may be recommended where a highly compatible repair material is needed.

UNDERSTANDING THE BUILDING

Assessing the condition of a ceiling may be relatively straight forward, or highly complicated, requiring expert advice from a structural engineer, or a conservation specialist. In any case, the plaster inspector should have an appropriate level of competence in the identification of materials, condition and repair of historic ceilings (see guidance box page 15).



Figure 7: a Victorian church ceiling remains seen to the bottom, with areas replaced in fibrous plaster (middle) and expanded metal lath and hard, pink gypsum (left).

Assessing condition may require sensitively opening up of floor or ceiling voids, in listed buildings this requires statutory consent from the local authority. Ceilings below roof voids may be subject to nature conservation legislation if protected species are present.

A ceiling can fail for a wide host of reasons, the full subject requiring a publication of its own. Reasons for failure need to be appraised by an experienced, competent assessor who will take a whole building approach to fully understand, diagnose and specify for repair. They will look at the structure, mechanical attachments, and many other environmental influences as a whole picture.

High quality individual technical elements, such as modelling or construction, increase the historical value of the entire ceiling. Intervention and management decisions must consider the whole piece.

Hand modelled plasterwork can further raise the historic value of a ceiling due to the time and skill involved indicating it was an originally an expensive commission. Surviving examples of historic plaster modelling are special and rare, more common on the continent of Europe where the trades had a tradition of including artistic

Assessment

training in contrast to the strict boundaries of English apprenticeship training omitting artistic study. Supporting a ceiling with hand modelling needs to be considered carefully, as does a ceiling with a pictorial oil painting. A painting or hand modelling may hold higher historic value and significance than the rest of the ceiling itself, or the flooring above. Ordering the building fabric in a hierarchy informs decisions on the best course of action or treatment.

Should any replacement repairs be required to an historically significant surface such as a painting, hand modelling or applied ornament then all involved need to be wary of conjecture or imposing a different to original tone or style when restoring any missing decoration. An example of conjecture in this context could mean assuming to add in a detail that we may presume was lost but have no definitive evidence of. As a legacy to future viewers or custodians of the ceiling it may be better to leave an area bare until evidence is found to confirm the missing features, rather than impose a uniformed guess that could be viewed by others as original.

When modelling or decorative painting require conservation, it is essential to commission a trained, specialist conservator. They should have relevant experience to the particular case they are commissioned for (see Competency text box). The conservation of wall paintings is a specialist field, to be carried out by specialist wall painting conservators only.

When considering recreating lost stucco modelling, especially figurative work, many of the most accomplished sculptors will be unaware of their own modern perspective with which they see and approach modelling. Modelling work by someone unaware of their bias will be obvious in contrast to the distinct style of a specific period and artist within a couple of decades.

“Choice of repair methods are guided by the significance of the building and the ceiling. The most significant ceilings require minimum intervention, reversible methods where possible and the possibility for re-treatability in the future.”

Conservation and repair options

The assessment process provides and understanding of condition, which will inform the range of appropriate options for conservation and repair, known as a feasibility study. This entail balancing heritage values, condition, context of use and risks to recommend the most suitable ones. In complicated situations and in highly significant and important ceilings the subject of heritage values requires a group discussion amongst the owner, surveyor, structural engineer, conservator, other experts and conservation officer. Multidisciplinary teams are essential to be able thoroughly understand ceilings, their significance, their relationship with the building that houses them and also their condition and repair needs.

Where buildings are listed, listed buildings consent (LBC) from the local authority will be required for the recommended repairs. Any building has the potential to be a heritage asset and have historic significance. Once the significance and value of a building are understood the repair methods can appear restricted. Proposals, however, are required to show proportionality. Conservation is the management of change - proposals balance the historic values with safety, and project restraints.

The best conservation principles may appear at first in conflict with project budget and time pressures, site restrictions or even safety but all of these are needed to be considered to arrive at a proportionate solution for a project.

When working on historically significant ceilings the guiding conservation principle of minimum intervention and re-treatability should lead the decisions for all the work. These principles can also guide best practice when considering historic building fabric of any age and status when balancing other project considerations for a proportionate solution.

COMPETENCY OF PLASTER INSPECTOR

A template for assessing competency in a plaster inspector is available on the FIS website. Devised for the inspection of fibrous plaster ceilings the form is equally applicable to traditional plaster ceilings. The forms can be used to assess contractor for conservation and repair competences.

[thefis.org/membership-hub/working-groups/heritage-plastering-working-group/heritage-buildings/](https://www.thefis.org/membership-hub/working-groups/heritage-plastering-working-group/heritage-buildings/)

ICON (Institute of Conservation) accredits conservation professionals many of whom are practicing craftspeople. Registered accredited conservators can be found at [conservationregister.com](https://www.conservationregister.com)

Icon also offers guidance on selecting a conservator [icon.org.uk/resources/caring-for-your-collection/selecting-a-conservator.html](https://www.icon.org.uk/resources/caring-for-your-collection/selecting-a-conservator.html)

FIS and Plaisterers Livery have rigorous qualification processes yet do not currently credit heritage plastering skills specifically.

Ensuring any new work is reversible allows for a better solution that may be devised in the future to be installed without the current work inhibiting it. Retaining as much original fabric as possible will enable any future works to have the best chance of success whilst retaining the historic integrity of the ceiling.

The principal concern needs to be to make the ceiling plaster safe from falling without damaging, or at least reducing any damage or loss to the original fabric or reducing the historic significance. A conservation repair is achieved by making the repair or the bond of

Conservation and repair options

the repair compatible with the original, alternatively making the repair softer or a sacrificial element so that any stresses or movement of the building over the years are expressed through the repair material rather than encouraging cracks and damage to the original plaster.

The combined materials of haired lime, laths, nails and timber joists form a structural system that can absorb and spread the influence of vibrations, thermal expansion and building shift across their whole. This dissipation of stress avoids concentrating shock on a focused point that can break ribs or cause cracks to start. Joists can shift in their mortices and absorb vibration along their length as can laths. The plaster itself is brittle yet with the inclusion of hair throughout the plaster can behave as a homogenous sheet until damaged. Conservation and repair work need to appreciate these properties to not cause future damage.

Replacement materials are ideally matched to the original. For example, the lime mortar making up the ceiling can be analysed so that a repair mortar can be devised to the same strength of lime and comparable ratio of similar aggregates along with their particle size. Matching mortar properties like this ensures that the old and new materials move in the same way at a micro level. Should a harder material be replaced next to original then this can encourage cracking and detachment of the original material. If any material is to be lost or damaged it should be that the later work is sacrificial in preference for the protection of historic fabric.

“Should a harder material be replaced next to original then this can encourage cracking and detachment of the original material.”

Repairing with appropriate materials and techniques

SITE CONSIDERATIONS

Temporary support

Identifying that a ceiling requires suspension works follows a crack or change in plane having been noticed or even a partial collapse. While the ceiling is being investigated, works specified and quotes gathered, it is of paramount importance that people are protected from risk of impact of falling debris and that the maximum amount of historic building fabric is supported in part or whole until the works can be actioned.

Ideally, the most immediate mitigating measure is to screw timber battens up to the joists through the face whilst stretching debris netting between the battens. Foam cushioning will be required where the battens cross raised ornament or touch a delicate surface and care taken when tightening the fixings and blocks used to raise the battens away from the surface. This method helps support some areas whilst catching any part that may release. It does, however, still risk the loss of some plaster.

LISTED BUILDING CONSENT

“... it is illegal to alter or demolish a listed building or any part without listed building consent.”

The methods described in this book are applicable to any traditional ceiling. If the ceiling or the building is a special example and considered important to the country, then it is likely to be a listed building. In England and Wales there are three grades of listed buildings, II, II* and I denoting if the building is of special interest, more than special interest or of exceptional interest nationally. In England these grades are determined by Historic England, the body advising the UK government on the historic environment or CADW in Wales. In Scotland the same scale of grades is listed C(S), B or A. In Northern Ireland B1/B2, B+ or A. The grades of building listing are to aid decision making when considering the significance of a ceiling or building but the rules protecting them apply equally to all listed buildings. The listed status covers the entire building, this usually includes any later alterations or additions that were present in and on the building on the date of listing including constructions within the grounds (curtilage). Scheduled Ancient Monuments can be ruins or uninhabitable buildings as nationally important archaeological sites and cannot be altered.

Craftspeople and professions alike must be aware that it is illegal to alter or demolish any part of a listed building without LBC (Listed Building Consent) from the conservation officer at the local planning authority. This means that even if a tradesperson has been asked by a client or architect to work on a listed ceiling the tradesperson can still be liable for prosecution if the work does not have permission. Like for like repair is often allowed without permission, depending on the significance, but this can be open to interpretation so if the materials and methods are not the same as original or any part is being removed then this may need LBC. For high status or significant buildings, it is always best to let the conservation officer know about any intended works to the building fabric. Early discussions can inform if the conservation officer thinks LBC is required or any conditions that would help the application. Should anyone involved in works to a listed building query if the project has LBC, and not see evidence, then they can look up planning applications on the local planning authority website and see if the specific work has approval and any conditions that need to be met.

Repairing with appropriate materials and techniques

As a short-term measure where the previous method cannot be fitted, boards with a tailored foam interface are propped from the ground by acrow props, adjustable scaffold pole or timber braces by an experienced conservation specialist. The design of these boards should be mindful of which areas need to be accessed from the face for repair works and the system supportive without allowing for movement on the floor above compressing the ceiling and causing further fractures and damage to the ceiling.

For particularly high ceilings a debris net can be stretched across the whole at a distance below whilst access is planned. Although this provides no protection to the historic plaster it enables the space to be safely used until works can be scheduled. The debris net, and more specifically the fixings need to be fitted and certified by a qualified company so also requires coordinating with the building's structural engineer. The fixings will usually need to be fixed elsewhere in the historic building fabric, so this option is not always viable even as a temporary measure.

Ceiling voids

If the void above the ceiling can be accessed then there is more choice of methods available for repair. Should access from above be viable the space and works require detailed risk assessment along with COSHH for hazardous substances that may be found there.

[hse.gov.uk/construction/healthrisks/hazardous-substances/lead.htm](https://www.hse.gov.uk/construction/healthrisks/hazardous-substances/lead.htm)

The ceiling voids will no doubt be filthy. In most undisturbed ceiling voids there is likely to be centuries of dust that has made its way into the void through floorboards or roof ventilation. Many voids reveal hidden rubble or even bird guano, carcasses, or rodent droppings. All of which will be contributing to weakening laths and nibs. Cleaning the voids is required prior to suspension methods and to reveal the extent of



Figure 8: layers of pug material (Darren McLean)

lost nibs and other damage. The weight of excess rubble, hidden as a convenience from past works, adds stress to an ageing ceiling and reduces the air flow through the void so needs to be removed.

Cleaning laths requires time and a gentle, considered hand so as not to cause further damage. Large rubble is picked off manually then a vacuum with brush head is held at a small distance to avoid any damage of the nibs. A soft bush is used to agitate the compacted dust and direct it towards the vacuum.

The ceiling and floor voids of many Georgian and Victorian buildings can contain pug or other materials fitted to provide sound, thermal insulation and passive fire protection (sometimes referred to as 'deafening' in some areas of Scotland). This original insulation needs to be considered for its historic value and structural attributes before being disturbed or removed. The most common pug is formed of laths fitted between ceiling joists with lime plaster spread on the upper side. Other variants can be thin planks fitted between joist and a bed of material laid on top such as charcoal, shells, or soil.

Opening a ceiling void can be the first sight since construction, vigilance is needed to note any artefacts or archaeology that can be revealed, even the ubiquitous alcohol bottles. If there is no curator or archaeologist for a

Repairing with appropriate materials and techniques

building then these should be logged and returned to the void once rubble is removed. Newspapers are often found that have been left as a document of the repair or even to stop a draught. These degrade so should be recorded, conserved and archived.

Protection of exposed laths and nibs is paramount for safety and conservation. Access needs to be cordoned off with a permit to work for the space, a site must not presume others know the delicate nature of laths. Exposed laths and plaster are frequently stepped on risking life and injury as well as the historic plasterwork.

Plastering, known as a 'wet trade', releases a lot of moisture both into the original building fabric and the air as materials set and dry. Relative humidity (RH) needs to be considered in delicate interiors and when treating significant surfaces and paintings by improving air flow. In a museum setting this consideration can be addressed along with the curators or objects conservators.

Exploring undisturbed voids and roof spaces can reveal the remains of rodents or beds of guano where birds have nested. All of these are hazardous to health so PPE is required for inspection including gloves, goggles and masks ideally face fitted to FFP3. Cleaning needs to be a coordinated effort between a professional cleaning contractor, the designers and the specialist plasterers with the experience of the space and materials obscured by the guano, ensuring contractors don't put pressure on the plaster, nibs, or joists that may move in their joints. A permit for work in confined spaces may be required depending on the characteristics of the ceiling void.

Modern insulation is often placed into ceiling voids and causes a great amount of damage to the nibs and restricts air flow facilitating mould and rot to set in to the timbers. Insulation and

ASBESTOS SURVEYS

Asbestos survey and management are legal requirements. If it is suspected that asbestos is present in a building, an asbestos survey should be carried out by an accredited or certificated surveyor. The objective of an asbestos survey is to:

- Identify the location, amount and condition of asbestos-containing materials (ACMs) and create an asbestos register and plan for the building
- Determine if remedial action is required
- Manage asbestos within a building
- Identify all the ACMs to be removed before refurbishment work or demolition.

There are two types of asbestos survey:

- Management survey to identify and manage risk
- Refurbishment or demolition survey in advance of building work.

Reference: Historic England.Guidance note HEAG269 Historic Fibrous Plaster
[hse.gov.uk/pubns/indg223.htm](https://www.hse.gov.uk/pubns/indg223.htm)

any other incumbent services introduced to a ceiling void should be safely suspended at least 100-200mm above the laths.

Lead

Many of the early layers of paint on historic plasterwork are likely to be distempers or chalk paint. Mid layers, just under the modern emulsions are highly likely to be lead paint. Lead is harmful to unborn fetuses and the development of young children and can also contribute to neurological conditions in adults. Craftspeople working on historic buildings need to be aware and mitigate risk of lead poisoning by covering wounds, wearing PPE appropriate to the level of risk and avoiding making lead paint airborne such by sanding.

Repairing with appropriate materials and techniques

In addition to lead, other heavy metals such as arsenic, mercury and cadmium were used in historic colours, these also carry risk to health.

Floorboards

Floorboards hold their own historic value and must be understood prior to any attempt to disturb them. Larger boards can attest to the client's status, getting the pick of a timber yard. The undersides can show the manner of sawing production and help date the work. Many will have tongue and groove or slips of timber that slot between boards keep them aligned. Damage to any of these should be avoided. For further advice on removal see the book, 'Historic England Practical Building Conservation' (Timber 2012).

When floorboards are removed to gain access to a ceiling below record the location of each board as it is removed to aid precise relocation. Not all boards should be lifted at once as their whole removal can reduce the lateral structural bracing they offer and release slight structural movement to the ceiling and other areas of the building. An engineer should be consulted if in any doubt.

“Animal hair was used as lagging around pipes so caution and awareness must be used when opening voids and environmental testing employed if any doubt.”

Bats

It is an offence to disturb roosting bats. Historic England advise that the presence of bats should always be assumed within historic roof voids unless a bat survey has been carried out within the last two years. Further advice, links and a webinar are available at historicengland.org.uk/advice/technical-advice/buildings/building-works-and-bats/

Anthrax

Anthrax spores can remain viable for centuries. The rare recorded infections in the UK in recent years were in the meat industry rather than construction. Spores are retained on hair from infected animals. To date anthrax has yet to be found on traditional plasterwork. Lime is alkali and historically used to kill bacteria so offers some protection yet awareness when handling historic plasterwork is vital. Animal hair was used as lagging around pipes so caution and awareness must be used when opening voids and environmental testing employed if any doubt.

Measures such as covering cuts, wearing gloves, good site housekeeping and hygiene should be enough to mitigate risks. Sourcing new hair through a traceable source will ensure that home sources and imports have been checked by a vet. Further advice can be found at hse.gov.uk/construction/healthrisks/hazardous-substances/harmful-micro-organisms/anthrax.htm

PATCHING IN

When patching in a lost area of plaster the surrounding surviving plaster needs to be stabilised with the most appropriate method, discussed in the section Suspension method. The practice of three coat lime plastering is discussed in other publications listed in 'Further reading' and in the Materials section. Details for patching in are discussed here.

Repairing with appropriate materials and techniques

Laths that remain in good condition following a plaster loss should be reattached with stainless steel screws. Snapped or lost laths need to be replaced with similar riven laths (where these are used originally) as sawn laths don't behave with the same flex or strength. Nibs snapped to the top side need to be cleared along with any other rubble to allow the new plaster to form nibs. Should access only be possible from below, then pairs of laths can be removed every 400mm or so to clear the void above and old nibs between the remaining laths. New riven or sawn laths, to match the originals, can then be screwed in to replace the missing ones.

The broken edges of the surviving plaster should be cut to a clean edge, some prefer to splay the edge to allow the most surface adhesion between the plasters and give the new plaster a little more hold. These edges are then primed with either a lime wash, a 1:20 conservation breathable primer or just water depending on the significance of the ceiling, then a preparatory application of mortar buttered on around these edges.

Original laths, with ingrained dust, will repel water and resist lime plaster adhesion so will require priming with a diluted primer 1:20 in water or for small areas rubbing with a wet brush will break down the resistance.

A lime plaster mix is best matched to the material properties of the original. Historic mortars can be analysed to create repair mortars that behave compatibly. New sand needs to be washed clean of salts and clays that can influence the shrinkage and other properties of the plaster. Where areas of original plaster have released, this material can often be reincorporated into replacement mixes for base coat.

The scratch coat is applied across the laths and worked into the recess of the original edge. The following coats are applied as described in the earlier passage Construction of a three coat lime

“Historic mortars can be analysed to create repair mortars that behave compatibly.”

ceiling. The float coat is levelled just below the original surface to allow for the approximately 3mm face coat and troweled to a finish.

Carbonation cannot be rushed. If the plaster is artificially heated then it will dry out without absorbing enough carbon dioxide so not achieving its full strength. Equally, the lime can dry too fast in direct sunlight so in this case will require protecting and kept humid with a sheet of damp sacking. Certain conditions can slow the set. If the building fabric is still wet from a flood or without windows and shrouded then the lime mortar will remain as a putty or wet product. Drying out a room with dehumidifiers will allow the plaster to carbonate at a steady speed. Industrial heaters will force uneven drying, cracking and result in a weak product.

The time needed between coats of lime plaster to gain proper strength can vary according to the relative humidity, from three days to two weeks. The plasterer's judgement and experience need to be respected and accommodated by the site manager or client to ensure a ceiling that will be secure and last. The works must not be rushed by applying too soon or including excessive additives. Surrounding heavy or vibrating works need to be scheduled prior to the plastering and the floor above protected from shock or vibration for weeks following, all of which can fracture the nibs whilst in their fragile state as they carbonate. Insulation fitted on top of the nibs can pressure and snap the nibs as well as restricting the carbon dioxide reaching the top of the plaster whilst the nibs are gaining their full strength.

Repairing with appropriate materials and techniques

CRACK FILLING

Cracks to historic ceilings need to be treated with either comparable materials or softer fills. A hard gypsum fill to a crack, for example, will eventually express as two cracks either side. Substantial cracks need to be cut or chased out minimally to provide a clear surface for the filler to adhere. Fine cracks, particularly on highly sensitive or significant surfaces can simply be washed out and fine filled. The surfaces are then primed with 1:20 conservation colloidal dispersant for significant ceilings, otherwise 1:20 PVA. Priming or prepping the surface is to slow the suction of moisture from the filler so that it does not dry faster than it can set. Ceilings that have delicate surfaces or decorative painting should be addressed by a conservator.

Cracks smaller than 5mm can be filled with a soft lime and fine aggregate mix, or a soft ready-made preparation without the inclusion of strengthening polymers. On highly significant surfaces the filler should be softer, and therefore sacrificial in preference for the original.

Cracks over 5mm need to be back filled with a typical 1:3 lime and aggregate comparable to the original plaster then finished off with face coat 1:2 as a filler. Mortars should be analysed, and the properties matched in the filler mortar for the fill to be compatible and behave in the same way as the original.

All fills will shrink slightly so should be initially filled proud of the surface. Once it has set it can be rubbed back to flush with a fine sandpaper.

GROUTING

Grouting means to fill a void. In the case of historic ceilings, the coats of plaster can delaminate from each other, especially in older buildings or those with heavy ornament.

The grout is usually injected into the void using a large syringe intending to fill the gap and re-bond the layers. Grout mixes are particular to each project and tailored to be appropriate to the specific mortar it is repairing. Grouts for lime plasters usually employ lime water or diluted lime putty mixed with fine aggregates ascending in particle size through each application. The plaster within the void will need to be flushed to encourage the flow of grout into the fissures and pores and a sure adhesion. The surface may require a prop to apply gentle pressure while the area and grout set to aid the bonding of original plaster layers. An experienced conservator must carry out this process as it can generate more problems deforming the surface and causing irreversible damage if applied incorrectly.



Figure 9: delaminated face coat and friable background, unsuitable for washer fixing, requiring both consolidation and grouting.

FAILURE - IDENTIFICATION AND SPECIFICATION

The majority of ceiling failures are due to physical impact and/or too many nibs missing. The nibs seen in figures 2 and 4 are the mechanical ties of the flat plaster to the structure above. Nibs can be most commonly damaged by impact, building vibration, unventilated voids, water expanding the laths and snapping the nibs or insulation compacted tightly above, to name a few causes.

Repairing with appropriate materials and techniques

“Decisions need to balance the various factors and pressures that are site and project specific as well as mitigating the causes of that failure in future.”

Laths can be released by their nails from the joists or the laths themselves may be too feeble or degrade over time.

When planning work and choosing the most appropriate method to support original plasterwork there is not one solution for all. Decisions need to balance the various factors and pressures that are site and project specific as well as mitigating the causes of that failure in future.

Roof and ceiling voids need to maintain an air flow to avoid damp and the risk of fungus taking hold. Coverings or obstructions such as sheet insulation or spray foam can inhibit ventilation and harbour future problems.

Many modern materials arise as cure all solutions to the issue of damaged nibs. Such preparations need to be approached with caution and tested in independent research to understand their behaviour over decades or centuries. Synthetic preparations can technically be hygroscopic yet not allow adequate movement of moisture through the material. Applications on top of ceilings cannot

be guaranteed to be removable and can obscure future inspections. Synthetic solutions could degrade at an undetermined rate so they need to be subject to laboratory accelerated aging tests to understand behaviour.

MODERN MATERIAL SOLUTIONS

New products may be developed to provide quick and easy installation solutions where traditional plasters have fractured or weakened.

However, practitioners and conservators should approach new products with caution and question if they achieve the treatment aims discussed on page 15.

- Does the new product restrict the options of retreatment in the future? Can it be removed or worked around if the original plaster degrades further?
- Is moisture able to pass equally through both sides of the plasterwork? Materials labelled ‘hygroscopic’ may still restrict moisture movement relative to the original plaster encouraging mould or rot.
- Does the new product add weight?
- Will the material degrade faster than the original? For example, foams or silicones can break down leaving a sticky mess within a few decades.
- Can the top side of the ceiling be viewed for future assessments?

If the long-term effects of a product are unclear, avoid its use.

Suspension methods

OVERVIEW

Below is a brief overview of suspension methods used for historic ceilings. Details of each method are expanded and illustrated in following pages. Assessments of each method are based on their compliance with conservation principles.

There are many more methods and variations beyond those listed. The following methods described focus on fitting of the ceiling suspension methods and the decision process required to select a method for varying situations.

	SITUATION	PROS	CONS
Screws and washers	<p>No access above ceiling.</p> <p>Face and surface finish of less historic value than the floor above.</p> <p>Only suitable if timber joists and laths in good condition.</p> <p>Plaster in good tensile condition with good hair content.</p>	<p>Relatively quick and direct attachment technique.</p> <p>Little or no disturbance to room and floor above.</p> <p>Cheap materials.</p>	<p>Not always suitable for highly significant decorative ceilings.</p> <p>Regular small losses to original ceiling face.</p> <p>Not suitable if delaminating.</p> <p>Not suitable if low hair content in lime.</p> <p>Not suitable where heavy ornament lies between joists.</p> <p>Less suitable for areas of great vibration or movement.</p>
Counter lathing	<p>Access available to both the face and upper side of the ceiling.</p> <p>Localised missing, damaged or rotten laths.</p> <p>Screws and washers preferred method.</p> <p>Nibs missing.</p> <p>Plaster in good tensile condition with good hair content.</p>	<p>Simple technique</p> <p>Cheap accessible materials</p>	<p>Small losses to original ceiling face.</p> <p>Not suitable if delaminating.</p> <p>Not suitable if low hair content in lime.</p> <p>Not suitable where heavy ornament lies between joists.</p> <p>Not suitable where original laths weakened or nails releasing.</p>
Perforated steel strap with wire and washers	<p>An additional device to screws and washers into the joists.</p> <p>When access possible to both face and top side of ceiling and a fixing is required between joists.</p> <p>When vibration is a risk to rigid fixings.</p>	<p>Fixing points adaptable to locations.</p> <p>Vibration and building movement absorbed by wire and not transferred to washer location.</p>	<p>Moderately time consuming</p> <p>Experience and discretion required.</p>

Suspension methods

<p>Perforated steel strap with dowel</p>	<p>Face of ceiling of high significance.</p> <p>Access available above ceiling.</p> <p>Ceiling subject to vibration, building movement or thermal extremes.</p>	<p>Does not punctuate face of ceiling.</p> <p>Can carry weightier ornament.</p> <p>Steel strap absorbs vibration from footfall and building movement.</p>	<p>Plaster needs to have good integrity surrounding fixing.</p> <p>Experience, discretion and dexterity required for fitting.</p> <p>Time consuming.</p> <p>Not suitable for inclined surfaces.</p>
<p>Wire and resin strip</p>	<p>Access above available.</p> <p>Face of ceiling significant.</p> <p>Missing laths or wide gap between laths.</p>	<p>Relatively simple to fit.</p> <p>Does not punctuate face of ceiling.</p> <p>Can spread influence across low ornament.</p> <p>Absorbs small vibrations.</p>	<p>Experience and discretion required for fitting.</p> <p>Simple materials.</p> <p>Moderately time consuming.</p>
<p>Gypsum tray method</p>	<p>Access above available.</p> <p>Damage to laths or nibs above yet layers of plaster bonded.</p>	<p>Quick and simple to administer.</p> <p>Cheap materials.</p> <p>Can offer protection to ceilings at risk of impact from above.</p> <p>Strong bond and wide influence.</p>	<p>Non-reversible.</p> <p>Adds weight to ceiling.</p> <p>Risk of lack of adhesion to ceiling.</p> <p>Changes nature of structural whole from flexible to rigid risking further cracking and detachment.</p> <p>Adds moisture at application.</p> <p>Resists moisture movement/evaporation risking lath and nail rot.</p> <p>Potentially damages painted surface.</p> <p>Scrim liable to deteriorate faster than lime ceiling.</p> <p>Impedes further inspection.</p>
<p>Polymer tray</p>	<p>Access above available.</p> <p>Damage to laths or nibs above yet layers of plaster bonded.</p> <p>Durability required.</p>	<p>Good surface contact to ceiling.</p> <p>Materials not liable to degrade.</p>	<p>Non-reversible.</p> <p>Introduces ridged strips to a flexible system so encouraging new crack locations.</p> <p>Localised moisture retention affecting painted surface.</p>
<p>Wire stapes</p>	<p>Damage to laths or nibs above yet layers of plaster bonded.</p> <p>Ceiling face of low to moderate historic value.</p>	<p>Simple application.</p> <p>Reversible.</p> <p>Cheap materials.</p>	<p>Only applicable on ceiling with exceptionally high hair content.</p> <p>Risks encouraging fracture in plaster along wire.</p> <p>Risk of long damage during application.</p> <p>Not suitable for significant ceilings.</p>

Suspension methods

SCREWS AND WASHERS

This is a very direct and simple method of tying back a ceiling to the joists where the ceiling has many nibs missing above, the most common of issues, or when the laths have released from the joists. The method illustrated to the left of figure 10, entails fixing screws and washers up from the face of the ceiling through into the joist above. Where the layers of plaster retain their bond well and there is a good distribution and quantity of hair contained within, each washer can achieve a wide circle of influence typically up to 450mm radius. The fixings can be removed in the future yet when the washers are countersunk the method includes the small loss of original material. The screw and washer method is frequently used in buildings where a cornice or other feature is of higher significance than the flat plasterwork.

It can be an effective solution where the flooring above is of a higher historic value than the face of the plaster ceiling or there are construction obstructions above. The method does entail drilling into the face of the plaster a collection of typically 25mm recesses to counter sink the washers to level. These can easily be repaired yet as this causes the loss of original surface material it is not suitable for ceilings with intricate ornament, with historic paintings or where the ceiling itself is of historic significance. It can be appropriate for lower value or more modern plain ceilings. The screws and washers need to be aligned to the joist in order ensure a secure fixing therefore it may not be suitable where heavy ornament lies between the joists.

Locations of fixings need to be minimal and carefully determined by the designer or competent experienced conservation craftsman. Fixings too frequently can encourage cracks and faults to form in an already weakened ceiling.



Figure 10: washer wire wrap method.

This method has been adapted for use on ceilings of exceptional value when the void above could not be accessed and the face of the ceiling held exceptional fresco paintings. The washers were not countersunk but sat on the surface, barely visible from the ground, but effective until another solution could be found.

Method

First the location of the joists above needs to be established from the face. This can be aided using a digital stud finder, measuring above and below or by drilling small pilot holes and marking the good fixings points on the face of the ceiling. The location should be away from any crack as further drilling can encourage a fault to become larger.

Once determined as a fixing location the hole is enlarged to be just wider than the thread of the screw to not cause new stress and crack the plaster. A drill bit larger than the penny washer eg 22-25mm bit is used to countersink the surface just deep enough to accommodate the washer and some fill material. Stainless steel fixings only are used, gently secured into the recess. Fitting the screw must be steady to avoid over tightening which could encourage new cracks from this location. The surface of the washer is covered with paper tape or similar, roughed on the surface to aid the filling material. The cut

Suspension methods

edges of the plaster recess can be wetted or primed prior to filling with a filling material softer than the plaster such as gypsum, lime and marble flour or Toupret, over filled, then sanded back to fair face ready for decoration.

COUNTER LATHING

When applying screws and washers to the face and access is available above, a suitable location can become apparent that lies between the joists. In this case it may be an option to lay a strong riven lath on top, perpendicular to the original laths to provide a stable location to screw up to. This method is in effect tying the body of the ceiling back to the structure with a mechanical fixing to replace missing nibs. It is not always suitable if there are well formed nibs nearby obstructing the new lath from lying flush. This method also needs to be administered sparingly to not add new weight to the whole.

Counter lathing can also be used to replace laths when only a few have weakened locally, for example, rotted from a localised slow leak. If the surrounding laths and nails remain viable

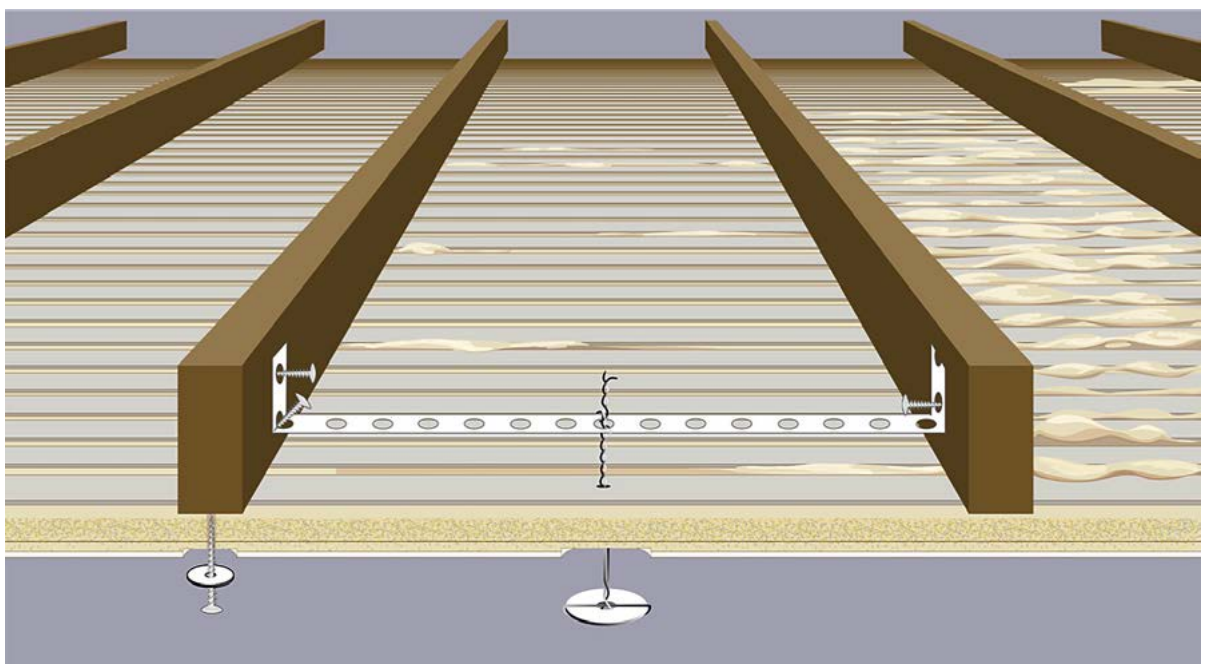
then the old laths can be cut away and counter lathed for screws and washers or localised tray method, expanded in a later section. The counter lath could be removed in the future should another method be required.

STEEL STRAP WITH WIRE AND WASHERS

This method, illustrated in figure 10, requires access both above and to the face. It works well on a ceiling that is not of the highest significance so that the washer can be countersunk into the face. The washer can be placed to carry an area that shows movement but the perfect fixing point is between joists. It can also be purposed to carry a weight of ornament if it is not bedded too deep in the detail otherwise it could encourage cracking or detachment of the ornament. It is not appropriate when the face of the ceiling is of high significance or has a decorative painting.

Fixing to a perforated stainless steel strap is slightly preferable than to a noggin or other rigid bridge as the steel strap absorbs the shock of any vibration or minor building movement in the same way that the laths

Figure 11: two alternative methods: washer and screw to the left; washer and wire wrap method to centre.



Suspension methods

nailed to the joists can absorb some shock without passing that onto the plaster and in turn cracking or damaging nibs.



Figure 12. Low level steel strap and dowel suspending a delicate painted ceiling. Note the traces of grouting to the right.

Method

The preferred location for a fixing is pilot drilled with a small bit up from the face of the ceiling. A coloured wire or skewer through the hole can ensure the strap can be fitted to exactly the required location. The steel strap is cut to the width of the joist bay with spare for attachment. This is then screwed into the sides of the joist with 30-100mm gap above the laths, fitting the strap taut.

A stainless steel washer is prepared by covering with masking tape and roughing the surface in order to aid shallow filling later as shown in figure 9.

The pilot hole is made larger than the double thread of the wire and the surface countersunk with a 25mm timber bit just deep enough to house the washer. Wire is passed through from the face and tied around the strap. The wire wants to be just tight enough to hold the washer snug without tying so hard it stresses the plaster and encourages a crack.

STEEL STRAP WITH DOWEL

This method, shown in figures 12 and 13, is one of the least intrusive to the face of the ceiling and with some careful work, could potentially be removed in the future so is considered reversible and a good method for ceilings of exceptional value and those with decorated surfaces. It can also be adapted to carry the weight of ornament without damaging the finished face of the work, particularly useful for high value and modelled ornament. Once the resin plug is set the system has a secure hold and a wide spread of influence whilst absorbing any building vibrations before they reach the stud and the ceiling.

This method needs to hang plumb so is not suitable for plaster on an incline or for the lower portions of a dome for example.

Method

The optimum location to lift the live area of plaster is located with coordinated measuring above and below. The steel strap is fitted taut across the joist bay where nibs are missing or the laths are weakening. Fitting the strap to one side first allows for the fixing points to be prepared and the dowels aligned with the strap prior to securing the steel strap across the joist bay.

Various clues from the surrounding area need to be evaluated to estimate the thickness of the plasterwork. Should the coats of the ceiling be particularly thin and light, then the broken stub of a nib could provide enough purchase for the system to hold. Once the hanging location is chosen and a pilot hole drilled to test the stable condition of the plaster then the drill hole can be widened to accommodate the dowel and opened into a 'fish-tail' or well to maximise the surface adhesion of the resin.

Suspension methods

Dowel lengths are cut to size with care to avoid damaging the thread. The nuts and washers are fitted to the thread and the steel strap prior to the gluing. The upper surface of the ceiling and within the drilled hole need to be completely free from dirt and dust. Flushing the area with acetone can increase the flow and clean the surface yet this shouldn't be tried with a painted face below and an assistant below in PPE needs to ensure it doesn't splash anyone.

The adhesive is a two part epoxy or polyester resin with a low thermal expansion during the set. Polyester resins tend to give of a strong smell so epoxies tend to be preferred for such interior work. The resin is mixed and worked into the well, around the stud and a small pile left on the surface so that once the stud is inserted the lower washer provides a wider footprint and influence.

WIRE AND RESIN STRIP

The method shown in figure 14 shows a slightly quicker alternative to the steel strap and dowel method yet what we gain in efficiency is to be balanced with the fact that this could be making

strips of the ceiling more ridged compared to the whole so in a space with considerable building movement or foot traffic above cracks could potentially form at these locations.

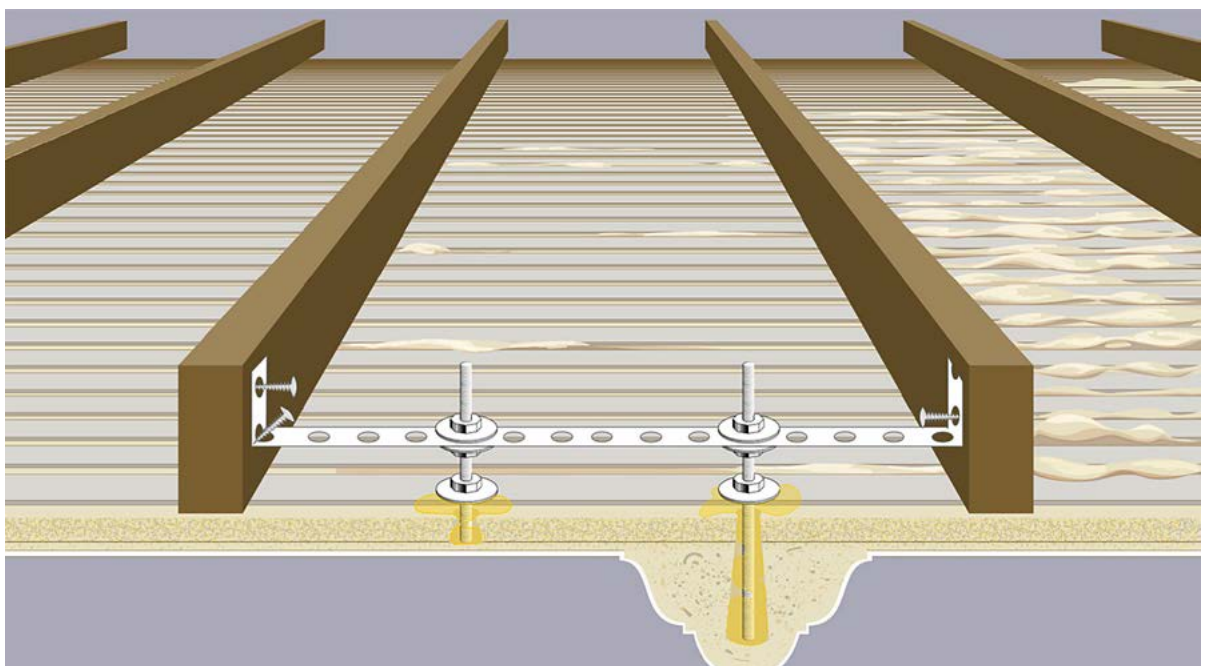
Method

Where laths have been lost or have a generous gap between a shallow even trough can be cut into the top of the plaster using a multi-tool guided on a batten or rule. Once the trough is cleaned of dust a substantial wire of >3mm gauge can be bedded in resin along the trough and fixed to the sides of the joists with screws or heavy duty staples.

TRAY METHOD - GYPSUM AND POLYMER

The plaster tray method, first published by George Bankart in 1927, is probably the most tried and tested method for tying the body of the ceiling back to the structure and has successfully held ceilings in place where others have failed when subjected to floods and other severe building trauma. This method, however, can also cause damage if used indiscriminately. It is not reversible and severely restricts future conservation options

Figure 13: steel strap and threaded dowel bedded in resin.



Suspension methods

so if used it should be when all other options have been exhausted and only administered sparingly in specific locations.

Where nibs or laths have been lost or weakened gypsum plaster is flooded over the surface and under the laths where gaps have formed, then a material such as scrim or wire mesh bedded in the gypsum and fixed to the joists. The intention is for the gypsum to adhere to the upper surface of the lime plaster and lock it back to the laths for the whole ceiling become reattached to the joists.

The tray method, seen in figures 15 to 17, first emerged with the advent of fibrous plaster which expired its patent and became a widespread ceiling manufacturing device from 1880.

The tray method is not advised as conservation best practice by Historic England and other conservation bodies for significant historic ceilings for a range of reasons:

- Ceiling wide treatment, as shown in figure 16, changes the structural behaviour of the ceiling from one that can accommodate minor shift and vibration making it ridged and enabling cracks eventually to form.



Figure 15: 1950s gypsum tray method to a dome post fire.

- The additional material adds significant weight to the ceiling and joists.
- The method involves a large amount of water that can damage delicate plaster or important painted surfaces as well as becoming entrapped and encouraging rot.
- This method is not reversible and so does not adhere to best conservation practice.
- There is no way to check that the plaster has adhered sufficiently to the original plaster.
- The gypsum tray obscures the nibs and laths from future condition assessments.
- Should the coats of plaster delaminate or the scratch coat detach from the gypsum then the options to save the area are severely inhibited.

Figure 14: wire and resin strip.



Suspension methods

- The integrity of the scrim is likely to degrade within 100 years, a much faster rate than the original materials that it intends to support creating future problems when the tray is no longer viable.



Figure 16: 1960s tray method with baton reinforcement.

The tray method can be very effective if used in small localised areas for example an awkward void at reach. This should only be used as a last resort when less impactful methods have been exhausted and used in the most minimal area and thickness.

At a much smaller scale the method can be used to tie back together breaks or tears in thin plaster that is high in hair content as is often seen in early or Elizabethan ceilings. Regular patches can create rigid areas amongst softer lime plaster encouraging cracks and potentially detachment at their junctions.

CAUTION: GYPSUM TRAY METHOD

The trays method is NOT advised as conservation best practice by Historic England and other conservation bodies for significant historic ceilings.

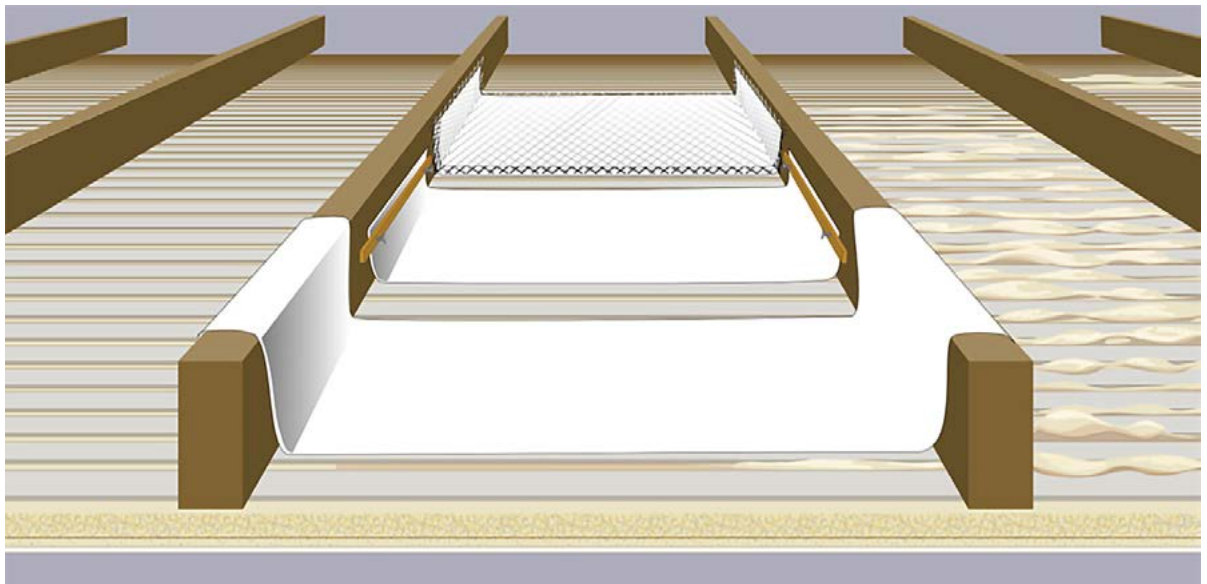
Method

There are many variations and preferences in methods. A few are described together here and illustrate in figure 17.

First the top side needs to be thoroughly but gently cleaned and vacuumed.

The surface of an historic ceiling repels water with all the ingrained dust resisting the adhesion of the wet gypsum plaster so

Figure 17: example tray methods from front to back - scrim and gypsum wrapped over joists; scrim and gypsum battened to joist; EML and gypsum.



Suspension methods

the surface tension needs to be reduced by either lightly washing water with a brush or priming with diluted conservation primer 1:20.

A soft general plaster such as plaster of Paris or fine casting is then washed over the top of the laths, attempting to flood between the laths and ceiling. A sheet of scrim is then soaked in the gypsum and laid over the tops of the laths and up onto the joists. At this point some have nails or screws to secure the scrim to the joists. In the example of figure 16 the scrim wraps entirely over the joists entrapping a baton at a diagonal, intended to add structural rigidity to the whole (in the same manner as many fibrous plaster large casts).

Another method entraps wire mesh and battens it to the sides of the joists. Another again uses minimal gypsum yet entraps wire that is stapled to the joist sides.

Some practitioners have preferred to remove laths to ensure thorough attachment to the face of the plaster. This is only advised if the laths are rotten and no longer viable. A ceiling of laths adds lateral stability to the structure of joists.

WIRE STAPLES

Also known as dog clips, wire 'staples' are U-shaped wires attached to the joists and designed to lift the plaster from the face and tie it back to the structure.

This method is relatively simple to install with accessible materials and can add a wide influence as the wires usually cross three to five laths. There is some loss of original material to the face so it may be appropriate for plain ceilings but is otherwise reversible as the wires can be released above and excavated from the face. The wires can absorb some building vibration yet easily transfer that to the face so this is not appropriate for buildings subject to much movement or heavy footfall. The wires can encourage cracks and faults in the scratch and float coats but can be stable if the original plaster has high hair content.

Method

Pilot holes are drilled from above at the sides of the joist to locate the optimum locations below. Recessed troughs are scored into the plaster, just enough to house the wire and cover space to fill. Wire is shaped with returns up at the end of each trough and secured to the side of the joists.

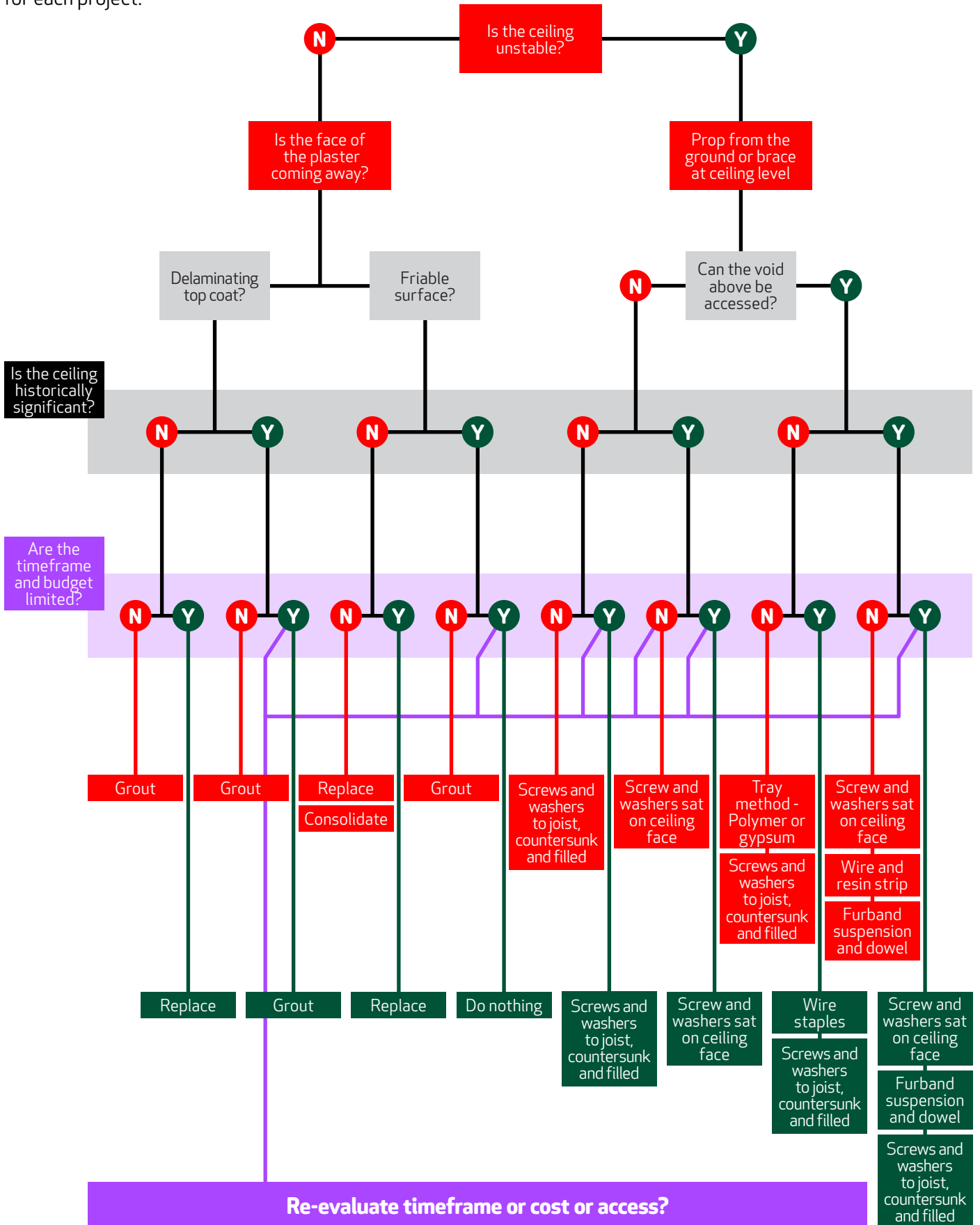
The trough is then primed and filled with a filler softer than the surrounding plaster.

Figure 18: example wire staples.



DECISIONS PROCESS

Use this decision-making matrix to devise an appropriate and proportionate treatment for each project.



Glossary of terms

Aggregate - sand or grit.

Architrave - framed moulding surround of an opening such as a door or window usually formed in timber or hard plaster.

Cadw - the historic environment service of the Welsh government.

Carton Pierre - a material used to form lightweight ornament. A mixture of animal glue, whiting, rye flour and paper pulp.

Composition (compo) - a hardening putty made from linseed oil, chalk dust and animal glue - boiled and pressed into moulds to form intricate ornament.

Conservation management plan - explains the significance of a historic building and sets out how any new use, alteration, repair or management will retain the significance. It sets out how conservation will be approached, both philosophically and in practice.

Consolidant - a liquid material that absorbs into a weak substrate, then hardens to strengthen the subject.

Counter lath - laying new laths at a right angle on top of the original laths.

Dowel - steel threaded rod or stud can fit nuts and washers.

Daub - an earth plaster made from earth or clay often with the addition of straw and cow dung.

Expanded metal lath (EML) - steel sheet perforated and expanded to form a lattice sheet material. Still used from the late 19th century to provide a surface for plaster to lock onto.

Fibrous plaster - a form of thin, light plaster prefabricated in large sheets laminated with jute scrim and thin timber reinforcement.

Friable - weak material condition where the particles are no longer adhering to each other.

Gauge - to add a measure of material to a mix to gain a certain characteristic such as hasten the set, harden further or make more plastic.

Gelatine - flexible material derived from animal bones.

Grout - a liquid mortar used to fill voids.

Gypsum - a naturally occurring mineral of calcium sulphate dihydrate, heated and powdered to create gypsum plasters such as plaster of Paris.

Joist - structural horizontal timber or steel across a void of ceiling or floor.

Lath, riven - thin timber lengths, a traditional pre-war method of making thin timbers by driving a blade or axe down the grain of a timber block in so doing retaining the strength of the natural grain.

Lath, sawn - thin timber lengths mechanically sawn that cross undulations of grain, giving a straighter but less flexible lath than riven.

Lime - material used for plaster or bonding masonry. Made by burning calcium carbonate in the form of chalk, limestone, corral or shells.

Lime putty - non-hydraulic lime (calcium hydroxide) in the form of a plastic putty, obtained by slaking quicklime in excess water. The best putty has been allowed to mature, sealed from the air and protected from frost. *(HE)

Hydraulic lime - (1) a lime with hydraulic properties which will set and harden primarily by chemical reaction with water. Such limes consist mainly of calcium hydroxide, calcium silicates and calcium aluminates. In conservation usage, the term mostly refers to natural hydraulic lime [NHL].

Glossary of terms

(2). In current standard designation, a lime with hydraulic properties consisting of lime and other materials such as cement, blast-furnace slag, fly ash, limestone filler, and other suitable materials. Currently designated HL and in most cases unsuitable for conservation purposes.

Hot lime - using calcium carbonate that has been burnt and powdered only, to create a quick lime. Mixed with sand and water onsite ready to use without the need to slake.

Hydrated lime - a general term to describe a quicklime that has been slaked industrially with a controlled amount of water, dried and powdered ready for mixing a mortar.

Historic England (HE) - the UK government's commission on the historic environment that issues best practice guidance and advises the government on the historic environment and listings.

Historic Environment Scotland (HES) - an executive non-departmental public body responsible for investigating, promoting and caring for Scotland's historic environment.

Listed building - buildings of special interest to the country have been 'listed', ie added to a government list of buildings deemed to have the most historic value or significance.

Listed building consent (LBC) - required permission from the local planning authority for all changes to a listed building. This can include substantial repair or similar interventions to the building fabric.

Nano-lime - a form of lime where the crystal particles are 100 times smaller than lime putty. Used for fine consolidation of wall paintings and some plaster ceilings.

Nib (key, lug, snot, hook) - plaster squeezed between laths to support the weight of the plaster.

Noggin - a horizontal timber member fitted perpendicular and between joists.

Parge (pargeting) - patterns in external plasterwork incised by stamping or combing, or hand-modelled relief ornamentation, typical of eastern England.

Polychrome - painted or pigmented decorative surface.

Papier-mâché - paper and animal glue pressed into moulds to produce lightweight ornament.

Pug - layer of lime mortar used as noise, fire or heat insulation suspended within the void above a ceiling.

Scrim - loose weave organic sacking like material made from the jute plant from India and historically woven in Dundee. The matrix material within fibrous plaster from 1855.

Society for the Protection of Ancient Buildings (SPAB) - an amenity society, founded in 1877, that advises on the care and development of ancient buildings and sites.

Stucco - a term used variably to describe all forms of plasterwork. Derived from the high German, then Italian, meaning 'to stick'. In recent years, it is used to describe fine modelled interior plasterwork, particularly associated with Italian speaking plasterers of the 18th century.

Vernacular - a local style or easily sourced local material, distinctive to a specific area.

Wad - a length of scrim coated in gypsum plaster primarily used to suspend fibrous plaster ceilings.

Wattle and daub - earthen clay applied to timber frames of buildings onto a mesh of woven twigs on stave rods usually of hazel.

Further reading

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RESOURCES

Historic England

historicengland.org.uk/images-books/publications/wall-paintings/heag101-wall-paintings/

historicengland.org.uk/advice/technical-advice/buildings/maintenance-and-repair-of-older-buildings/temporary-protection-historic-features-building-works/

Online PDF advice

historicengland.org.uk/advice/technical-advice/buildings/technical-conservation-guidance/?utm_medium=email&utm_source=newsletter&utm_campaign=brand

Listings and map

historicengland.org.uk/listing/the-list/
historicengland.org.uk/advice/planning/consents/

Fibrous plaster advice

historicengland.org.uk/advice/constructive-conservation/conservation-principles/

Historic Scotland

Gibbons, P, Newsom, S and Whitfeld, E (2004); Care and conservation of 17th century plasterwork in Scotland. Historic Scotland Technical advice note 26.

Simpson and Brown Architects, revised Scottish Lime centre (2002). Conservation of Plasterwork. Historic Scotland Technical advice note 2.

Further reading

Building Limes Forum - latest information, courses, annual conference

buildinglimesforum.org.uk

ABTT Guidance note 20 on the inspection of fibrous plaster ceilings

abtt.org.uk/wp-content/uploads/woocommerce_uploads/2019/09/ABTT-Guidance-Note-20-19May2015.pdf

Claire Gapper's website - papers on British renaissance plasterwork

clairegapper.info

British history online, including the Survey of London

british-history.ac.uk

Society for the Protection of Ancient Buildings (SPAB)

spab.org.uk

Buildingconservation.com

buildingconservation.com/articles/articles.htm#plasterwork

Churchcare

churchofengland.org/resources/churchcare/advice-and-guidance-church-buildings/conservation-reports

Endorsements

CISCA

Ceilings and Interior Systems
Construction Association

The American journey is enriched by the contributions of artisans worldwide, each imparting their unique techniques. A comprehensive document outlining best practices for preserving and repairing lath and plaster serves as a valuable resource in safeguarding this rich historical narrative.

Paul Gallagher

CISCA (Ceilings and Interior Construction Association), USA



HISTORIC ENVIRONMENT SCOTLAND | ÀRAINNEACHD EACHDRAIDHEIL ALBA

It's a document written for the trade, by the trade, and I think that gives it some strength and relevance.

Roger Curtis MRICS

Head of Technical Resources, Operations Directorate, Historic Environment Scotland



THE WORSHIPFUL COMPANY OF
PLAISTERERS

With so many wonderful historic buildings within the United Kingdom, many in need of restoration and repair, this guide will be a useful touchstone for professionals within the building trade and historic conservation area. The Worshipful Company of Plaisterers, an ancient Livery Company of the City of London, is pleased to endorse the guide and hopes that it will be of value in conservation work across the UK.

Garth Manger

Clerk, Worshipful Company of Plaisterers

Founded upon a lineage of craft skill, knowledge and experience this ably-prepared technical guide on the conservation of historic plaster ceilings is to be warmly welcomed. The clearly presented wealth of understanding effectively integrates conservation pragmatism with appropriate philosophy and ethics, to aid and support best practice decision-making.

It provides essential reading for all professional disciplines involved in the repair, maintenance and conservation of historic buildings. To ensure the longevity and integrity of the significant legacy we have inherited, readers are expertly guided through a familiarity of materials, their capabilities and risks, with appropriate options and actions being offered.

The informative texts and supportive illustrations also consider interim possibilities that can arise, leading to a balanced tabulated overview of repair techniques.

Finally, the succinctly summarised decision-making tree helps ensure that the guide's underlying wisdom and comprehension can be readily pursued to achieve the most appropriate remedial outcomes.

Ingval Maxwell OBE

Former Director, Technical Conservation, Research and Education, Historic Scotland Chair, Edinburgh Group

Endorsements



I believe that this up-to-date summary of current conservation principles will be a very useful document not only for architect and surveyors but also for conservation plasterers. While it is not an instruction manual, it is certainly a very useful reference publication.

Sean Wheatley

Sean Wheatley Plastering Specialists



This guide provides an excellent overview to the range of plaster ceiling issues which can be encountered on historic ceilings, and it showcases the variety of methods available in which to treat them. I'm sure it will be a useful resource for historic building homeowners and heritage professionals alike in promoting best practice.

Spencer Hall ACR IHBC MCI0B

SHHBC Conservation Consultant

A useful technical guide on how to assess and repair lath and plaster ceilings for those not familiar with the issues and complexities, that will hopefully encourage greater understanding and care.

Fleur Gordon

Head of Skills and Crafts, Land and Nature



FINISHES & INTERIORS SECTOR

BEST PRACTICE GUIDE **REPAIR OF HISTORIC CEILINGS**

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