Gypsum Plaster Floors

SPAB Regional Technical Advice Note

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This Technical Advice Note aims to help prevent continuing unnecessary damage to gypsum plaster floors in old buildings and, consequently, the United Kingdom's built heritage. Such floors have a long and rich history in areas with gypsum quarries. These are found most notably in the English Midlands but also counties elsewhere, including Yorkshire, Sussex, Somerset and Cumbria.

Once associated with high-status construction, gypsum plaster floors eventually became ubiquitous in many categories of building. Their popularity declined in the 19th century. Today, they are commonly unrecognised and widely mistaken for later concrete construction. Even where accurately identified, gypsum plaster floors are often wrongly perceived as inherently inferior to modern flooring. There is also little appreciation of their historic value or advice for those wishing to keep old gypsum plaster floors in use.

This advice explains how repair and retention is frequently practical.

Cover image:
The historic gypsum plaster floor in the Great Chamber at the Bede House, Lyddington, Rutland. Photo: Douglas D Kent

1 Introduction

A gypsum plaster floor comprises a screed typically 40-75 mm thick containing gypsum (hydrated calcium sulfate) as the primary binder mixed with various other ingredients. This mix is laid over a suspended timber structure or, less often, solid base. In addition to gypsum and related minerals, the plaster contains materials such as charcoal and unburnt coal, limestone, burnt lime, sand and, in crushed form, tile or brick. Some ingredients were incorporated deliberately in the past, including those intended to give bulk, but others may have become part of the plaster incidentally due to crude production methods and the gypsum being over- or underburned to varying degrees.

Historically in the UK, gypsum plaster floors, like other types of plaster floor, were an advance on basic earth flooring. They had attributes that led to their use in preference to timber floorboards while, near to the natural raw materials, were still economical. They provided a hard, durable surface that was draught-free and warm under foot, gave good sound insulation, offered fire-resistance and were less vulnerable to rot and vermin damage than floorboards.

Another very interesting, practical function was as master masons' drawing or tracing floors. Here full-scale drawings and designs for window tracery, arches and vaults could be inscribed into the soft surface of the plaster for modelling stonework. Examples remain in York Minster and Wells Cathedral.

The composition of a gypsum plaster floor was determined by what materials were to hand locally (See figure 1(a)).

Depending on the constituents, the overall colour of gypsum plaster floors varies from creamy to a nondescript or dark grey, due in part from the ash of wood or coal, to a pink-reddish hue, influenced by brick dust or fragments (see figure 1(b). Many of the contents are visible with the naked eye or a x10 hand lens, especially after the surface is wiped with a damp sponge. These might include, for example, opaque blue/grey or near translucent particles of anhydrite, a mineral frequently found with naturally occurring gypsum. It is the varied composition of the mix that provides an important characteristic of gypsum plaster floors and helps distinguish them from concrete or cement screeds.

The presence at ceiling level of organic bedding material (for instance, reed or straw) can provide a further clue to the existence of a gypsum plaster floor, as does a suspected pre-20th century date (see figure 2). In addition, unlike with concrete or cement, the surface of a gypsum plaster floor is scratched easily with a sharp knife and 'rings' when gently tapped. Be mindful, however, that gypsum plaster floors may well contain some later cement repairs.

Although the binder is sometimes partly lime-based (indicated by the presence of calcium carbonate), floors of gypsum plaster differ from those bound principally with lime as generally found, for example, in south-west England. Aggregates in the latter display

Figure 1(a)

Figure 1(b)

Figure 1: Samples of old gypsum plaster floors:
(a) typical colour and texture, and; (b) the varied composition found.

Photos: A J Goode Ltd (a) and Douglas D Kent (b)

a more limited range of colours and fewer pink or red particles. This distinction between gypsum and lime plaster floors is important when formulating repair proposals. Cost-effective up-to-date laboratory analysis is available to aid the accurate identification of the principal binder.

Confusion has frequently arisen over the identification of gypsum plaster floors and those based on lime, which has not been aided by past terminology.1 For instance, according to the literature 'alabaster floors', 'plaster concrete', 'lime plaster floors' or 'lime-ash floors' all sometimes seem to have been terms for gypsum plaster floors. Even today, the term 'lime-ash floors' is much used, misleadingly, as a generic name for both lime and gypsum plaster floors.

Surviving gypsum plaster floors are usually of historic significance and worthy of conservation. In many cases, they are original to a building, or date from an early phase in its construction, and this authenticity contributes notably to the property's special interest. An important characteristic of many old plaster floors is their patina, highly polished appearance and gentle undulation caused by centuries of wear and settlement, which enhances the unique atmosphere of old buildings (see figure 3). Gypsum plaster floors also reflect vernacular building traditions and help create a sense of local distinctiveness. Additionally, the varied range of constituents in such floors can provide aesthetic appeal. Most gypsum plaster floors are simple and were covered with matting in living spaces but for more refined interiors could sometimes be laid to imitate stone. Regrettably, these floors seem to be treated with less respect than other surviving historic fabric in old buildings and are commonly replaced with alternative materials. Replacement also sometimes occurs because of misguided concerns over the strength or insulating properties of gypsum plaster floors in comparison with modern construction.

This Technical Advice Note considers next the history and construction of gypsum plaster floors (sections 2 and 3). A sound understanding of these aspects will help enable a proper appreciation of the significance of such floors. Good information on the history and construction of gypsum plaster floors also provides information essential for the analysis of any defects and effective repair (section 4), the methods and materials for which are described later (sections 5 to 8) along with care and maintenance (section 9). Technical terms used in this guidance are defined in our online glossary.[2]

Figure 2: The presence of organic bedding material, such as reed, can indicate the existence of a gypsum plaster floor. Photo: A J Goode Ltd

Figure 3: The patination from years of wear in a gypsum plaster floor at The Triangular Lodge in Rushton, Northamptonshire. Photo: Douglas D Kent

2 History of use

Knowledge of how to produce gypsum plaster stretches back to the ancient world in prehistoric times.[3] This insight was exploited in the Middle East during the early Neolithic period around 8 000 BC, where gypsum plaster was used originally for floors with the development of permanent dwellings. It provided these early roundhouses with flooring that was durable and easy to keep hygienic. They typically featured quadrantal mouldings at the abutments with the ancillary walls to form skirtings that aided cleaning.

Floors have traditionally been constructed of gypsum plaster in parts of Europe, such as the Andalusia region of Spain (see figure 4). In the UK, its use for the construction of floors appears to stretch back to the 13th century, following a visit by Henry III to France. Gypsum plaster floors were laid initially in important areas of royal palaces. One of the earliest documentary references relates to the supply of plaster of Paris for the floor of the Jewel Tower, London in 1365-6.[4]

By the 17th and 18th centuries, gypsum plaster floors were popular at a humbler level, for example, in farmhouses, cottages and outbuildings/agricultural buildings. According to Nicholson, gypsum was:

'much used in Derbyshire, for laying the floors of cheese-rooms, granaries, &c. After preparing it in the usual way, they mix it with water, and spread it on the floors about 2½ inches [65 mm] thick, which, when dry, forms a smooth surface and durable flooring, the whole expence [sic] not exceeding 1s 6d per square yard.'[5]

Floors of gypsum plaster also found favour in the service areas of country houses, such the attics accommodating servants' quarters.

Gypsum plaster was used predominantly on first and second floors, presumably because it is moderately soluble in water so more susceptible to erosion at lower levels. More examples are emerging at ground floor level, however, where they are found on solid bases rather than suspended timber structures. The geographical distribution of gypsum plaster floors may also be wider than previously thought as small deposits of gypsum occur in many parts of England. Laboratory testing will help establish exactly where old gypsum plaster floors exist and the SPAB is always interested to hear of further examples that become known.

The use of gypsum plaster floors slowly declined during the 19th century because of changing fashion, the introduction of woodworking machinery and reduction in the price of floorboards, along with the abolition of duty on timber. Timber floorboards became a popular and economical alternative.

Sophisticated techniques employing durable gypsum-based pigmented plaster to achieve decorative marble-like effects were imported to England from Italy in the 18th century. Such plaster, known as scagliola, is used for floors but is beyond the scope of this Technical Advice Note.

It should be noted that various salt solutions can be added to gypsum to produce patent plasters, including Keene's cement. This was sometimes specified for floors in the 19th century.

Figure 4: Cane bedding forming the underside of a historic gypsum plaster floor in Sierro, Andalucia, Spain. Photo: Douglas D Kent

3 Construction

3.1 Gypsum

Gypsum is a mineral also known as calcium sulfate dihydrate, which has the chemical formula $CaSO_4 \cdot 2H_2O$. Although naturally occurring, gypsum may also be produced synthetically as an industrial by-product. The water combined within gypsum ('water of crystallisation') can be removed by various degrees of heating ('calcining') to create different end products.

When gypsum is heated in air between about 150 and 160 °C it is partially dehydrated and yields the hemihydrates of calcium sulfate ($CaSO_4 \cdot 0.5H_2O$). These are better known as plaster of Paris – so named because it was first imported from the quarries at Montmartre near Paris. Heating gypsum to higher temperatures drives off more water of crystallisation. At 180 °C, the nearly water-free anhydrite ($CaSO_4 \cdot nH_2O$) is produced and above 250 °C the completely water-free anhydrite ($CaSO_4$).

Plaster of Paris will revert to the more commonly occurring dihydrate again upon the addition of water, with the resulting paste hardening or 'setting' rapidly in ways useful for casting and construction. Chemically, the end result is the same as the natural gypsum, hence the term the 'gypsum cycle' (see figure 5). Modern bagged plasters contain retarders to slow down the speed of set and also include fillers and other additives. By contrast, fully water-free anhydrite does not readily react with water, unless an accelerator is added.

The scientific analysis of old gypsum plaster floors indicates that most contain a binder consisting of a combination of gypsum converted from plaster of Paris and varying amounts of anhydrite. The mineral anhydrite occurs naturally with other forms of gypsum while also being produced by overburning gypsum. It is quite likely that crude early calcining methods inadvertently (if not deliberately) created the anhydrite. Its inclusion would have had the advantage of extending the working time for laying a floor and providing it with a harder finish.

Where ash occurs in gypsum plaster floors, it tends to be present in small quantities and was probably a result of the calcination process, rather than deliberate addition as a separate aggregate. If lime is present, this is sometimes in a sufficient quantity to suggest its deliberate incorporation as a binder. In other cases, though, any lime identified is far less significant and indicates accidental inclusion, perhaps, for instance, from bedding mortar that adhered to old bricks crushed up and used in the aggregate.

Early methods of producing gypsum plaster were seemingly more haphazard than today. In the UK, records indicate how production in the past was carried out by burning lumps of gypsum rock close to the source of supply in the open, using fires with wood or coal that could be alight for several days (see figure 6). John Farey in his General View of the Agriculture and Minerals of Derbyshire noted this process in 1813:

'The process of burning and preparing plaster for floors … is the most wasteful one that can be imagined: an immense pile of brush and billet wood was made, and upon it the old plaster and some new … was laid, and fired: after which, a number of men with flails, thrashed, and rather wasted and spread it about than pulverised it'. [6]

After this burnt gypsum had been broken down and ground into powder, water was added to produce a coarse plaster for flooring.

More economical means of production evolved as demand increased. Easily obtainable gypsum stone of a poorer quality was quarried that was unlikely to have been considered for high quality plaster. Kilns and pan calciners were used for burning the gypsum instead of open fires and mechanical means of crushing components rather than flails. [6]
Referring to old plaster being broken down and reused as aggregate when floors were relaid, The Builder noted in 1854 that:

'it is considered desirable that a certain proportion of old plaster should be mixed with the new; when that is the case the floors are found to set harder'. [7]

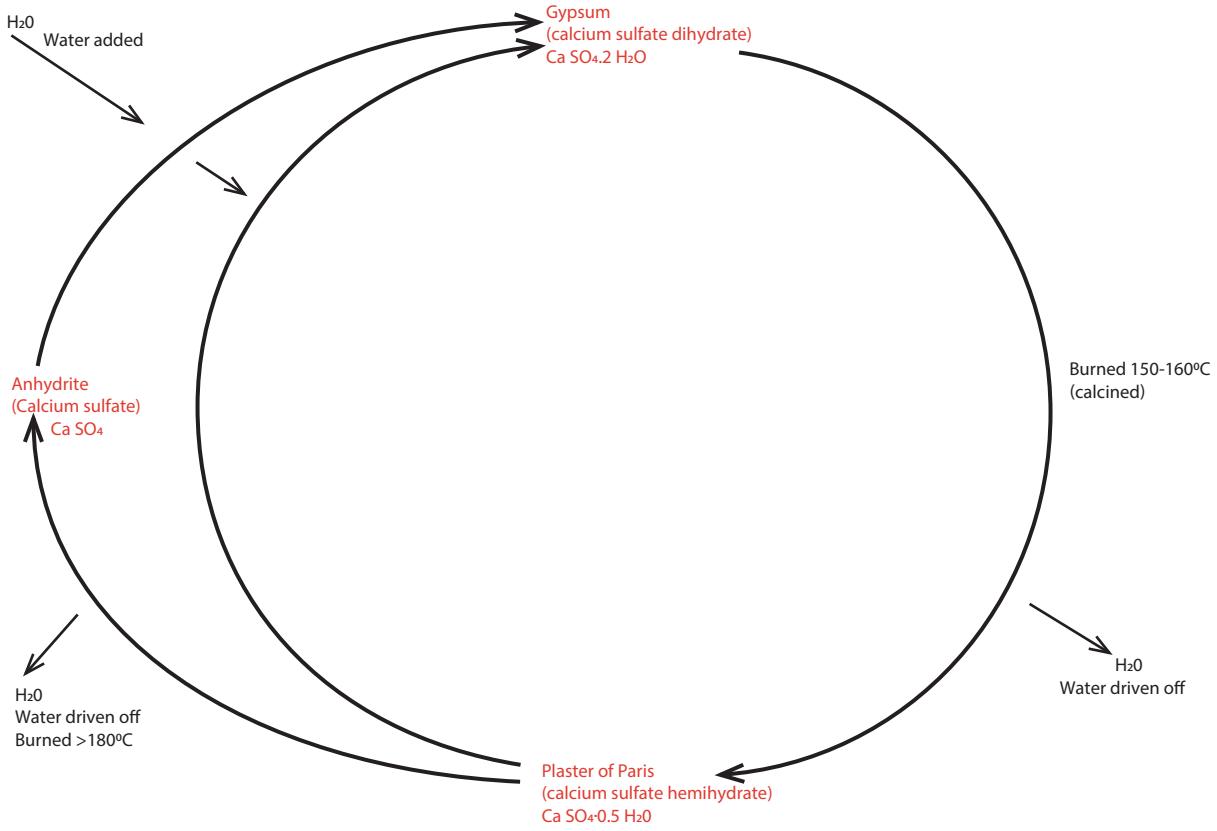

Figure 5: The gypsum cycle. Illustration: SPAB

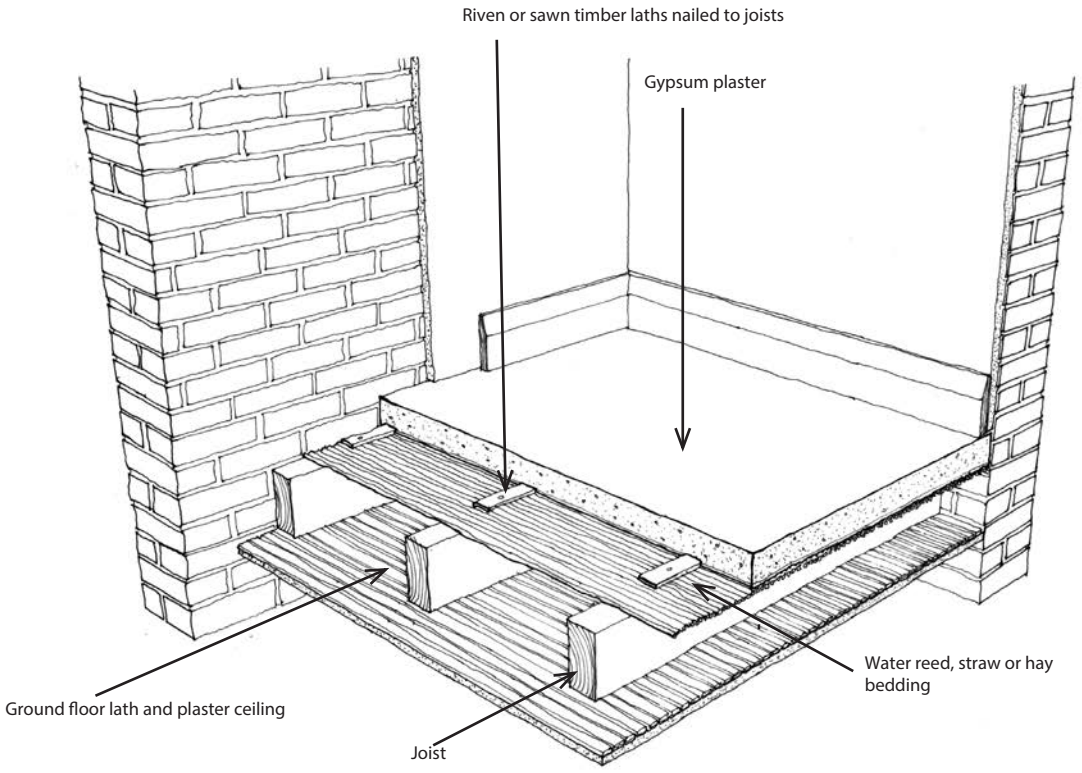

Figure 7: Cutaway of a typical gypsum plaster floor. Illustration: Ross Perkin

3.2 Bedding, floor structure and base

The surface of a gypsum plaster floor consists of a rigid slab formed after the mix was trowelled on wet, usually as a single layer. The bed onto which the plaster was normally placed varied regionally and could be of water reed, hay or straw held down by riven or sawn timber laths nailed across the top of timber floor joists (see figure 7). Such bedding probably adds little to the ultimate strength of the floor but supported the mixture while still wet, like shuttering. A variation has been noticed in high status buildings where riven hardwood laths were nailed to the joists before the bedding material was laid (particularly where hay was used) (see figures 8(a) and 8(b). In rare cases, the plaster was spread over boarding.

The joists supporting gypsum plaster for upper floors were generally laid in the same way for conventional floorboards. The relative lightness of gypsum plaster once set enabled slimmer joists to be employed, though, which saved timber and would have allowed appreciable cost savings in comparison with timber-boarded floors. The joists and supporting beams in more modest buildings were very often of unseasoned timber, generally oak.

The underside of the bedding material for a gypsum plaster floor was left exposed or plastered between the joists. Alternatively, in better quality work, a separate lime plaster ceiling might be applied to the underside of the joists. Occasionally, the space between the joists of attic floors was filled with a lightweight sound insulating material, such as chaff or even nutshells.
With ground floors, the gypsum plaster is cast directly over compacted earth, hardcore or stones. A well-drained base of this nature helps protect the floors from rising dampness and aids their durability (see figure 9).
Occasionally, a decorative effect was sought. One unusual late 18th- or early 19th-century example of a solid gypsum plaster floor in Leicestershire appears to imitate more expensive stone. It comprises black and white 'tiles' of gypsum plaster laid on a bed of compacted earth and coal chippings. The plaster was cast in situ, which enabled tighter joints to be achieved than with precast tiles. The white 'tiles' were formed as one layer but the black ones as two (a lower part of white plaster plus an upper layer blackened with fine coal dust) (see figures 10(a), 10(b) and 10(c).

3.3 Finishes

Millar records that bullock's blood was used to harden floors after they were dry.8 The Builder in 1854, however, commented that 'it is also usual to give a[n] increased hardness by a coat of linseed oil, and in Nottinghamshire the floors are painted and look extremely well'. Rush matting was commonly used historically as a covering for gypsum plaster floors in living areas.

Figure 6: Trial gypsum-burning on an SPAB course. Photo: Douglas D Kent

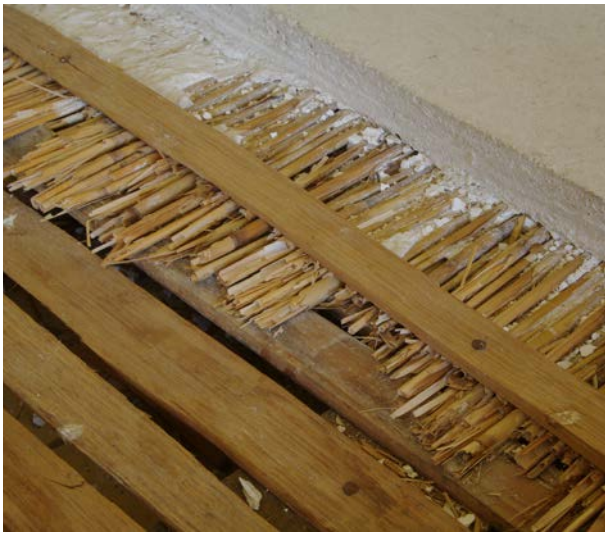

Figure 8(a)

Figure 8(b)

Figure 8: Organic bedding material: (a) reed, as seen in a sample box cutaway, and; (b) laths. Photos: Douglas D Kent (a) and A J Goode Ltd (b)

Figure 9: A stone base for a new gypsum plaster ground floor.
Photo: Douglas D Kent

Figure 10(a)
Please see below

Figure 10(b)

Figure 10(c)

Figure 10: A historic solid gypsum plaster floor at Scraptoft, Leicestershire laid to imitate tiles: (a) general view; (b) alternating black and white 'tiles'; (c) the two layers forming a black tile.
Photos: A J Goode Ltd

4 Defects and deterioration

4.1 Diagnosis

Knowledge about the history and construction of gypsum plaster floors will assist with the diagnosis of any defects. Once the nature and cause of defects are established, an appropriate form of repair can be implemented to maintain the integrity of the floor yet retain as much of the original fabric as practicable. Many old plaster floors continue to be serviceable but over time can become heavily eroded, weaken or fail (see figure 11).

It is important to carry out a thorough inspection to identify any defects within the gypsum plaster, bedding material or base. Much can often be gained from a visual inspection. There may, however, be an additional need for limited investigations including the sensitive opening-up of concealed areas.

Where a floor is damp due to an overlying impervious floor covering, such as foam-backed carpet or vinyl sheeting, this should be removed to aid drying. Moisture contained within the floor cannot evaporate otherwise and condenses instead on the underside of the covering. The condition of the floor can only be assessed properly after it has reached equilibrium with its surroundings. The floor may dry out satisfactorily without the need for more extensive and expensive measures. It should not, therefore, be instantly condemned and replaced.

Bear in mind that intermediate floors provide restraint for enclosing walls in many old buildings so are fundamental to their structural integrity. Where doubt exists about the stability of a floor or supporting components, reference should be made to a suitably experienced structural engineer. The SPAB may be able to suggest the names of engineers who might be contacted.

4.2 Abrasion and impact damage

Minor abrasion is to be expected but gypsum plaster floors may deteriorate more seriously due to:

- Localised wear. This arises from excessive foot traffic in doorways, passageways or even rooms. The surface will also become polished and, where grit is trodden in, pitted, which exposes and loosens aggregate, and leaves the floor vulnerable to further erosion. Sharp-heeled shoes are particularly damaging.
- Scratching and gouging. Plaster floors are susceptible to impact damage from the careless movement of heavy furniture.
- Harsh brushing. Stiff bristle brushing can exacerbate deterioration, particularly of floors suffering from dampness.

Figure 11: An old gypsum plaster floor may look beyond repair but can frequently be brought back into a sound, functioning condition.
Photo: Douglas D Kent

Figure 12: The nature and causes of defects should be clearly established before carrying out work involving an old gypsum plaster floor.
Photo: Bonsers Restoration Ltd

4.3 Distortion and cracking

Many old plaster floors are uneven and distorted but this does not necessarily indicate ongoing or recent movement causing damage that requires attention. Gypsum plaster floors may distort and crack for various reasons, leaving them more susceptible to abrasion, impact damage and, in extreme cases, collapse (see figure 12).

- Overloading. Joists may be weakened or fractured where they support heavy objects or increased loads, for instance, following the sub-division of large rooms with new walls or where a building changes use. Misguided attempts are also sometimes made to level-up floors by overlaying them with concrete or cement screeds. The weight of this can cause distortion, especially where a floor structure has already been weakened. Further attempts to level a sagging floor with inappropriate materials will frequently exacerbate the deformation.

- Differential movement. Cracking may occur at the interface between gypsum plaster and incompatible cementitious repairs. This leaves the floor vulnerable to abrasion and impact damage.

- Movement or decay of supporting timbers. Many original suspended plaster floors probably settled unevenly early in their history. This is because the timber supporting structures in more modest buildings were often built of unseasoned timber that twisted as it dried out. More serious, ongoing movement may result, however, from the decay of joists or beams, where dampness promotes beetle infestation or fungal attack. Deformation and cracking can also result from settlement, subsidence or the outward movement, or removal, of supporting walls.

- Loss of bedding material. Localised subsidence can occur due to insect attack, associated with dampness, or rodent damage. It will be most obvious if there is no ceiling below.

- Movement of solid base. Ground floors may suffer localised subsidence where their base settles, perhaps due to poor compaction during laying or changes in moisture levels (for example, due to alterations in drainage patterns) or the presence of tree roots. Floors can also be undermined by burrowing rodents.

4.4 Breakdown of plaster

Gypsum plaster can deteriorate for several reasons:

- Dampness: The floors of older, traditionally constructed buildings, which normally perform best without damp-proof membranes (DPMs) to stop moisture rising, can suffer from groundwater problems. This may occur, for example, where a water table has risen or drainage problems develop. Because gypsum is moderately soluble in water, it will break down when subjected to excess moisture, particularly over long periods. Deterioration is exacerbated where soluble salts are present. These crystallise within the pore structure as moisture evaporates, causing the surface to crumble.

- Problems are compounded where impermeable floor coverings, such as vinyl sheeting and foam-backed carpet, or surface sealants trap moisture. Leaking water pipes and roofs, or water penetration through exterior walls, can cause severe localised decay in gypsum plaster floors. It is strongly advisable to seek advice required with diagnosing a major dampness problem separately from quotations for work to address it. Taking such advice first (for example, from a chartered building surveyor or other appropriately qualified individual) will prevent vested commercial interests giving rise to recommendations for more work than is strictly necessary (which can occur when a remedial treatment contractor is asked to both diagnose and resolve dampness).[9]

- Strong detergents and other cleaning products: Gypsum plaster can be adversely affected by cleaning agents that introduce soluble salts into floors.

- Inappropriate repair mixes: Gypsum plaster floors are sometimes overlain or partially replaced by concrete, or a

cement screed, in a misguided response to cracking or surface irregularity. Delamination of the later, harder plaster often occurs with movement in the underlying structure.

4.5 Damage from installation of building services

Floors can be compromised by the installation of buried services, such as plumbing and electrical cabling:

- Chasing of plaster: The plaster itself is frequently damaged when cut out to insert pipe or cable runs.
- Notching or drilling of timbers: The slender joists of many plaster floors may be seriously weakened by notches or holes formed to accommodate services.
- Disturbance of bedding: Reed, straw or hay and the laths used to hold them down may be absent where cut out, and require reinstating before plaster repairs are undertaken.

Figure 13: The special interest of an old building is best protected with conservative repair. Photo: Douglas D Kent

5 Work in general

5.1 Conservation approach

The demands of conservation impose additional considerations when working on an old building. In particular, a number of overriding principles should be borne in mind when dealing with gypsum plaster floors, in addition to the specific methods described later (sections 6 to 8).

The SPAB exists foremost to promote 'conservative repair'. For the Society, the value of an old building lies in its antiquity through the mental association this evokes (see figure 13). It believes that the special interest of old buildings is best protected by maximising the retention of their historic fabric while minimising any disturbance affecting the overall essence.

The SPAB's view is that conservative repair is achieved by adhering to the following key principles:

- Carry out work essential to the long-term wellbeing of an old building
- Employ compatible methods and materials, and
- Obtain sound information about the history, construction and condition of an old building, as well as user needs, before making any serious interventions.

Listed building consent may be required from the local planning authority for replacement of a gypsum plaster floor or other work that exceeds like-for-like repair – if in doubt, consult the conservation officer. It is a criminal offence to carry out work that needs listed building consent without obtaining it beforehand.

5.2 Good information

It is strongly advisable to obtain advice from a suitable specialist familiar with working on gypsum plaster floors when work is required (see section 10.1).

Well-meaning but misguided jobbing builders who lack the necessary mindset, skills and experience often undertake harmful

work on old buildings. In particular, be wary of anyone who suggests the removal of a gypsum plaster floor that is merely worn or suffering from an unresolved structural problem. It is vital to identify and remedy the underlying causes of any problems before embarking on plaster repairs (see section 4).

While many constituents of a plaster floor mix can usually be readily identified visually, the presence of others will often only be ascertained by laboratory analysis (see figure 14 and section 10.1). Such analysis is normally essential, therefore, to formulate a suitable plaster mix for repairs. It is important when sampling historic plaster floors to ensure the sample being analysed is representative of the inhomogeneous material. Take care not to inadvertently select inappropriate later work. A range of simple and sophisticated analytical techniques is available to establish the ingredients and their proportions. Be sure, however, to employ an experienced analyst who can interpret the resulting data accurately.

It is good practice to record the condition and appearance of the floor before commencing repair. Photographs are satisfactory in many cases but sketches may sometimes be helpful in addition. A good record of the work should also be made (including the results of analysis).

5.3 Essential work

An abstemious approach should be adopted that prioritises repair in situ over wholesale removal and replacement, which is justified only where absolutely necessary. Gentle wear and undulations in old floors are signs of age and can confer beauty. They deserve respect and are not blemishes to be eradicated. Good preventative maintenance will not only restrain, or even obviate, the need for repairs in the first place, it will prevent the loss of original fabric and is also cost effective.

Be mindful of not inadvertently taking up a historic floor when removing a more recent concrete screed or slab on top of the plaster.

Where a new use is planned for an old building, ensure that the proposals consider the capabilities of existing plaster floors at the design stage to help prevent unnecessary damage or loss to them.

5.4 Appropriate methods and materials

Methods and materials should be chosen to ensure that the appearance and performance of repairs correspond, as far as possible, to those of the original floor (see figure 15). A sympathetic match is important not only for aesthetic reasons but also to help ensure good durability. Cement or lime plaster

Figure 14: Drilling to remove a core sample of a gypsum plaster floor for laboratory analysis. Photo: A J Goode Ltd

Figure 15: Materials and methods for repairs should match those of the original gypsum plaster floor as far as possible. Photo: A J Goode Ltd

should not, therefore, be used as a substitute for gypsum plaster of a suitable composition.

Sample boxes (containing plaster laid in advance of the main work, to demonstrate that the workmanship and materials match the originals) should be prepared on all jobs wherever possible. Once workmanship and finish standards have been agreed, a suitable sample can be used as an exemplar for the remainder of the project. The production of sample boxes also allows the practical aspects of different mixes to be assessed, such as setting times.

Defects in the supporting timber structure causing deterioration should be addressed before the plaster is repaired. Minor carpentry repairs are preferably carried out in situ, where possible, to minimise disturbance to the floor. Some temporary propping may be prudent to ensure a safe working environment during repairs.

6 Preparation

6.1 Removal of existing plaster, concrete or cement screed

Where the removal of old gypsum plaster is justified, as much material as possible should be salvaged because it can usually be crushed and reused in new plaster (see figure 16).

When removing inappropriate concrete floor slabs or cement screeds, trial excavations should be made at several locations to establish whether the material has been laid over an earlier gypsum plaster floor (or other historic surface). If a historic floor surface is discovered, the concrete or cement should be removed carefully because it may be possible to repair the underlying material.

Figure 16: Old gypsum plaster that is removed should normally be retained for use as aggregate when laying replacement flooring. Photo A J Goode Ltd

Figure 17: New reed bedding being laid.

Photo: A J Goode Ltd

Figure 18(a)

Figure 18(b)

Figure 18: Bedding material being dressed: (a) with lime putty; (b) over which, as in this demonstration, gypsum plaster is laid.

Photos: A J Goode Ltd and (b) Douglas D Kent

6.2 Repair or replacement of bedding or base

The bedding or base of a floor may require repair or, if unavoidable, replacement before new plaster is laid (see figure 17). Repairs should normally be like-for-like in terms of methods and materials, including any used for sound deadening.

Where complete renewal is warranted, however, the opportunity could be taken to upgrade the performance of the floor, if appropriate. For example, the thermal properties of a ground floor, although good, can be enhanced further by laying the plaster over insulating loose fill rather than more conventional compacted hardcore or earth. The loose-fill layer is overlain with a permeable membrane to stop the wet plaster seeping down into the fill.

Notwithstanding this, the SPAB has a presumption against the insertion of DPMs in old floors. DPMs prevent solid floors from breathing and, by displacing moisture into the bases of adjacent walls, may cause rising dampness.

New bedding material should be cut and laid on the exposed joists. This is then held in position by fixed laths on top of the joists. The bedding material can then dressed with lime putty, if identified in the old floor. (See figure 18). Alternatively, it may be appropriate to use fine hay or straw to fill the gaps instead of a lime putty dressing where the bedding is of reeds.[10]

It is generally unnecessary to reinstate lost bedding material where a section of ceiling is being replaced providing this is localised between joists and it does not provide the backing for a ceiling below. The plaster will usually span the joists safely and the underside can be concealed behind a new section of ceiling on separate lathing.

7 New plaster

7.1 Plaster selection

Standard mixes are not appropriate because of the wide variation in the composition of gypsum plaster floors. When undertaking repairs, the existing plaster should be analysed and trials undertaken (see section 5.2) to ensure that a compatible mix is employed.

If a floor is beyond repair, perhaps due to extensive collapse, a plaster mix can be selected to meet the required aesthetic and performance criteria. The modern requirements of a floor may differ to those of the past.

7.2 Gypsum

Modern plasters are invariably different to those found in historic floors due to today's production processes. Plasters nowadays are purer and lack the inclusions that characterise old gypsum plaster. Two types of gypsum plaster have so far been used to repair and replicate plaster floors with some success.

First, a high-strength hemihydrate plaster[11] with a setting time of approximately 35 minutes. This shortens when the new plaster is mixed with old reconstituted plaster floors, requiring a retarder to provide sufficient laying and levelling time. Secondly, a high-impact finishing gypsum plaster,[12] giving a much longer setting time. Either plaster works well though given the choice, some consider the latter to be preferable. Selection depends largely on the size of repair being undertaken and number of workers to optimise the working time.

It is advisable to add a retarder to provide sufficient laying time before the plaster sets. Possible retarders are trisodium citrate, decorator's glue size mixed with hydrated lime or natural keratin glue. Some experimentation is advised, however, because using too much can reduce setting capacity.

7.3 Aggregates

Where possible, any gypsum plaster removed from a floor should be crushed and reused as aggregate in new plaster, as was frequently done historically. This helps ensure the visible aggregate matches the old floor, particularly as the surface wears and the old particles become exposed. New plaster is added to the aggregate in proportions identified by analysis.
If recycled material is not available, many of the materials found in old plaster floors can be substituted by adding a selection of new aggregates to the plaster. Gypsum rock and anhydrite are not readily available **but can be sourced**. Other ingredients, such as brick or tile, sand, coal, charcoal, stone, limestone or burnt lime are available. Most, though, will have to be crushed to an appropriate size, or purchased ready prepared, and then blended if a good match and colour is to be achieved.

7.4 Mixing

Laboratory analysis of original material is important because it not only establishes the binder but also the type and proportions of aggregates needed if as near as possible a repair is to be achieved, and is probably more economical than a trial and error exercise (see section 5.2). Whether using original crushed flooring material or processed aggregates identified visually, guessing the quantities for new mixes is inadvisable and time-consuming.

The main issue affecting the mixing of plaster for a floor is the volume of water required (before it is added to the blended aggregates). The water content for the plaster is found in the product information sheets but more may be needed for dry aggregates. This can be estimated by adding a measured volume of water to a measured amount of dry aggregate. For example, if 1 kg of dry aggregate absorbs, say, 300 ml of water without excess, multiplying the water content to the weight of aggregates used in a mix will give the extra water needed.

Mixing for relatively small areas can take place in a plasterer's bath using rakes or shovels, or a heavy-duty electric drill and whisk designed for the purpose, and for larger scale works a cement mixer (see figure 19). In both instances, the dry blended material is scattered into the container holding the measured volume of water. The resulting mix should be fluid and easy spreadable.

Figure 19: Mixing gypsum plaster in a plasterer's bath.
Photo: Douglas D Kent

Figure 20(a) Please see next page.

7.5 Laying

To experienced plasterers familiar with modern floor screeds, laying gypsum for a plaster floor is not dissimilar except the mix will be more fluid and, depending on the type of plaster used, can set more quickly. Buckets or wheelbarrows may be used to transport the mix but care needs to taken when walking or wheeling up to, and placing the mix onto, a fragile bedding material. The floor is laid between timber battens that are removed to allow the laying of the sections in between. The plaster is levelled to a uniform thickness with a long wooden float and the surface finished with a steel or wooden float as works proceeds (see figure 20). It can be difficult, however, to achieve a good match because most floors are highly polished after years of use and this effect is extremely hard to replicate in a repair.

When reed or straw bedding was used in the past, a regular practice was to spread onto this an initial, quite thin, layer of lime putty to prevent the main mix, which can be fairly fluid, running through any crevices or small holes. An alternative to lime putty dressing, as mentioned above, was to use fine hay or straw to fill gaps between reeds. Where the underside is to be plastered between the joists, though, plaster can be left to run down between the bedding material and then floated off from below to form the pricking-up coat for the ceiling.

For larger areas, a reasonable amount of time will be needed for repairs, once laid, to cure and harden before they can cope with foot traffic and longer for loading, possibly from two to four weeks.

Figure 20(b)

Figure 20: New gypsum plaster being: laid between temporary timber battens (b) levelled with a wooden float. Photos: Jamie Miles

8 Repairs

8.1 Scope

Minor cracking and surface spalling due to wear and tear is generally not a serious problem providing the floor structure below is sound. Cracks and spalling can be made good but are probably best left alone. Where deterioration is more extensive, repair will need to be considered and is not as difficult as frequently assumed. It can range from filling a crack to the partial replacement of a floor.

8.2 Repairing cracks and holes

Holes from redundant pipe or cable runs can be filled, as can wide cracks if stable.

Cracks and fractures should be raked out carefully to a depth sufficient to provide a good key for the repair mix, their edges undercut and loose debris removed. Damaged areas, large or small, should be cut back as far as the middle of the nearest supporting joist beneath sound flooring. Gypsum floors are quite soft and cutting can be done with old wood saws, hacksaw blades or, in highly experienced hands, mechanical tools, particularly those with oscillating blades. Electric drills and masonry bits may be used to form a series of close holes, weakening and controlling removal without using a 'heavy hand'. Core bits of various dimensions are available for most sizes of hole formed during plumbing, heating or electrical work. Care must be taken to ensure that vibration does not damage adjacent ceiling plaster.

It is important that the raw, undercut edges of the floor being repaired are dampened with water to control suction from the new plaster mix before it is inserted. The new plaster should be finished flush with the existing surface (see figure 21).

To make good isolated sections, cracks and fractures, refine the crushed material to an aggregate size appropriate for the width of the gaps. The repair is made easier by the slight expansion of gypsum as it sets, which will close the joint crisply between the existing and new flooring.

8.3 Making good minor areas of surface spalling

Surface depressions can be made good, where necessary, using new gypsum plaster spread over the defective area after first undercutting the edges of the existing, adjacent plaster. In more serious cases, where filling is not practical, an area of disintegrating plaster will need removing and re-laying (see figures 22(a) and 22(b)). Care should be taken to minimise damage to attached bedding material.

No attempt should be made to seal powdering surfaces because this may well exacerbate damage (see section 4.4).

Figure 21(a) Please see below.

Figure 21(b)
Figure 21: Cracking in gypsum plaster: (a) raked out for repair; (b) filled with a matching new mix. Photos: Douglas D Kent (a) and A J Goode Ltd (b)

Figure 22(a) Please see below.

Figure 22(b)
Figure 22: Patch repair: (a) new plaster being spread over a dressing of lime putty; (b) finished level with the existing surface. Photos: A J Goode Ltd

9 Care and maintenance

9.1 Good practice

Good care and maintenance of gypsum plaster floors helps ensure their long-term survival. This should include regular monitoring of any surface deterioration or cracking.

9.2 Cleaning and surface treatments

Plaster floors should be regularly swept or dry vacuumed on a low suction setting to remove dirt and dust.

Rugs, mats or loose carpets are best lifted first. Gently loosen any embedded dirt by dry bristle brushing but avoid aggressive wire brushing or similar, as this will cause damage.

Cleaning the floor judiciously with warm water and a sponge, after sweeping or vacuuming it to remove any abrasive material, can reveal the colour and texture of the surface. Place doormats at entrances to catch dirt and reduce abrasion to floors by grit taken into the building.

In most cases, proprietary surface treatments are inadvisable. Such products can greatly accelerate deterioration (see section 4.4).

9.3 Floor coverings and protection from impact damage

Natural, breathable coverings, such as loose carpets or mats, can help protect a gypsum plaster floor. Rush matting is a noted traditional covering but requires dampening down weekly to prevent embrittlement. More convenient alternatives are made today from sisal, coir or hessian-backed woollen carpet.

Foam-backed carpets or other impervious coverings should be avoided because these will seriously compromise air circulation below and may cause dampness to form, leading to degradation of the floor. Where carpets are laid, a suitable material comprises an 80% wool/20% nylon mix laid over a natural colour, natural fibre contract quality hair/jute underlay. It is best to use runners or loose-laid carpet. Sticking on underlay or other materials is not recommended. It not only makes future removal very difficult but also the glue might have an undesirable effect on the floor.

Plaster floors are quite strong but relatively soft, so vulnerable to sharp, pointed objects that will cut into the surface. High-heeled shoes, therefore, should not be worn on unprotected floors. Floors can also weaken from point loading or impact from heavy house or office furniture. Problems may be avoided by the selection appropriate furnishings, careful positioning of furniture around the edges - not in the centres - of rooms and possible use of boards to spread weight. Additional protection can be afforded by using castor cups beneath furniture.

10 References

I Wright, 2005, p143 comments on how authors in the ancient past appear to confuse gypsum and lime generally

2 See:
https://www.spab.org.uk/advice/glossary

3 Ibid

4 Taylor, 1996, p6 states that Henry de Yevele, deviser of the King's works of masonry, 'received individual payments for supplying plaster of Paris for rendering the floor of the Jewel Tower'

5 Nicholson, 1841, p337. John Speed, writing about Nottinghamshire in the 17th century, commented that: 'betwixt the Joysts they lay only long Bulrushes, and thereon spread this Plaister, which being thoroughly dry becomes most solid and hard, so that it seemeth rather to be firm stone than mortar, and is trod upon without all danger'

6 Farey, 1813, p16. Nicholson, 1841, p181 describes how the material for gypsum plaster was brought to London in crude state, then calcined and ground in a mill

7 *The Builder,* 25th March 1854, p149. Farey, op cit, p16 also notes 'the plaster of old floors being burnt, and mixed with fresh Gypsum, with good effect'

8 Millar, p498

9 For more on treating dampness problems, see SPAB Technical Advice Note on:
Control of Dampness

10 Stafford Holmes has reported to the SPAB that he has seen the use of fine hay or straw as an alternative to a lime putty dressing on old gypsum plaster flooring at Hardwick Hall in Derbyshire

11 Saint-Gobain Formula 'Crystacal R' or equivalent

12 Tarmac Tilcon or equivalent

11 Other advice

11.1 Contacts

Where work to gypsum plaster floors is being considered, the SPAB may be able to suggest suitable specialists, including contractors and structural engineers. If plaster analysis is required, the SPAB may also be able to provide the names of firms with testing facilities.

11.2 Further reading

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This publication is dedicated to the memory of Anthony J Goode (1945-2018), who died during its production. Anthony's contribution to the cause of the SPAB was immense and he will be remembered for his kindness, enthusiasm and willingness to share with others.

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