# TRADITIONAL SOLID GROUND FLOORS

PAUL WATTS and GILLIAN TESH

*Medieval encaustic tiles in a church in Malvern, their pattern worn away over the centuries: laid on a solid floor in lime mortar, clay tiles provide a traditional solution to the need for durability and permeability.*

**AT GROUND** floor level, solid floors of compacted earth predominated throughout the world until relatively recently and they remain common in many poorer countries, particularly in rural areas. At their most basic, they are readily eroded and become dusty. One option is to use a covering, the simplest being loose rushes. Another is to apply several coats of a drying oil such as linseed to consolidate the surface.

From the earliest civilizations, wherever harder-wearing surfaces were required, floors have been finished with embedded stones, tiles, bricks and mosaics, resources and status permitting. These could be laid directly onto the earth flooring, or bedded on sand, often over rubble hardcore.

The Romans left us a legacy of beautifully inlaid floors, and in 13th century England, glazed clay floor tiles started to reappear, bedded in lime mortar. Brick floors appeared in the following century and were normally used for passageways, sculleries and outbuildings.

Some traditional solid floor materials tend to allow the passage of moisture vapour from the ground through them, whereas slate and some other impervious stones might allow it only via joints.

An alternative to earth floors was the use of lime or gypsum. The Romans created a form of cement based on slaked lime mixed with volcanic ash and an aggregate which included crushed brick. The ash had a pozzolanic effect, enabling the lime mix to achieve a hydraulic set before the mortar had fully dried out, while the brick particles helped it to dry and may also have contributed to the hydraulic properties too. (A hydraulic set is one which is not dependent on the presence of gaseous carbon dioxide, and in a damp floor this can be important.) Although much softer than the cement used today (ordinary Portland cement), this cement was surprisingly durable and was used for a range of building purposes, not just floors.

Although Roman cements ceased to be widely used after the fall of the Roman Empire, lime-ash floors – which came into existence perhaps around the 14th century – bear a close resemblance. They comprise slaked lime and wood ash from lime-burning kilns, together with aggregates and often gypsum. These floors hardened to such an extent that the material is sometimes mistaken for concrete. Lime-ash floors are found at ground level and at first floor level, often supported on a layer of reeds over the joists and hidden from below by plaster and lath ceilings. Cotehele House in Calstock, Cornwall, a Grade I listed mansion (built c1300 with later phases of alteration), has an impressive lime-ash floor dating from 1520.

Suspended timber floors appeared in the UK in the early 18th century. Air flow was maintained between the ground and the timbers above by vents in the external walls, to ensure that the air did not become too damp.

Until the early 20th century, most floors were vapour permeable to some extent. This changed with the advent of ordinary Portland cement (OPC), which became widely available in the interwar period and is relatively impermeable. Furthermore, damp-proof membranes were introduced at the same time, enabling floor slabs to be created that were water-tight. Later it became standard practice to include a layer of insulation under the concrete slab too. This form of floor construction is now standard in modern buildings.

Today's building regulations and standards require the solid floors of most buildings to have high levels of insulation and high compressive strength as well as impermeable barriers to prevent moisture migrating through the floor into the room. The building regulations and standards are absolute for new dwellings and are the goal for existing buildings, but they can be a little more flexible if there are good reasons not to conform to the letter.

## TRADITIONAL OR MODERN

Like the majority of traditional building materials and techniques, a traditionally constructed solid floor is 'breathable', allowing any moisture present in the floor to evaporate into the air. Provided that the ground is

adequately drained, and the room above is adequately ventilated, a permeable ground floor can allow equilibrium to be reached between the ground and the air above, reducing the chances of concentrated damp areas which can cause the building's fabric to deteriorate.

### Traditional earth floors

Due to their density and low thermal conductivity, earth floors which are dry are thermally efficient, capable of absorbing heat and releasing it gradually over time – the thermal 'flywheel' effect. English Heritage, in its guidance note *Energy Efficiency and Historic Buildings: Insulating solid ground floors*, observes that 'the ground itself maintains a surprisingly stable temperature of around 10°C'. For these reasons, earth floors are among the most sustainable forms of flooring, and there has been a revival of this type of floor construction for domestic situations by the environmentally-conscious.

However, from a commercial perspective, laying an earth floor is extremely labour-intensive and time- consuming, and has long-term maintenance implications. Earth floors do not always tolerate load points and in damp climates like the UK, managing groundwater is an issue.

### Modern earth floors

Preventing ground water penetration is best achieved by incorporating some form of 'capillary break'. This can be an impermeable damp-proof membrane (DPM) as is common in the US and would usually include petro-chemical based insulation. An arguably better approach is to use foam glass or expanded clay aggregate insulation as a base. Made from recycled glass or clay, these are in many ways more sustainable than an insulation based on petro-chemicals, despite the energy used in reprocessing them. (Particular environmental concerns raised by insulation materials like polystyrene include the environmental impact of the gases used to foam them,and of the litter from waste material.) Furthermore, due to the open pore structure of an insulation layer created with these aggregates, there is far less capillary attraction to draw moisture into the base of the walls.

### Modern concrete floors

The modern approach of making floors impermeable with a DPM and concrete is designed to work with a building of modern design and construction which incorporates a damp proof course in the walls. A modern floor design with a DPM and concrete may work well in a traditional building too if the groundwater is minimal, but all too often the capillary effect of the substrate draws groundwater to the underside of the floor slab where it accumulates. However, as the surrounding footings remain porous, they act like a wick, drawing the water up. Evaporation concentrates at the base of the wall, just above ground level. This can lead to excess moisture at the junction of the wall and floor, and mineral salts can be drawn into the structure. This excess moisture can cause simple discolouration, failure of decoration or plaster or degradation of structural timbers or earth walls. Salt crystallisation in particular can be highly damaging to some types of masonry.

## CONSERVATION OF TRADITIONAL BREATHABLE FLOORS

William Morris, one of the founders of the Society for the Protection of Ancient Buildings, said: 'We are only trustees for those that come after us'. It is important to remember this when making alterations to historic buildings. Even if the building is not listed, is it right to remove flagstones or a lime-ash floor that have been part of the building for centuries? Will this damage the character that an interior acquires with age, or, worse still, the structural integrity of the building?

Homes and workplaces need to be functional spaces where people can live and work comfortably. Increasingly, they also need to be energy efficient, satisfying the ever-growing demand for carbon reduction while retaining their distinctive character. It is a difficult juggling act but it is very satisfying if it can be mastered. Inevitably, compromises will have to be made by owners, conservation officers or building control inspectors, and sometimes by all three.

If the building has an original feature floor or one that is historically significant, is it practical to retain it? Even if the floor is not perfect, can its idiosyncrasies be tolerated? A little undulation here and there or higher moisture level at times may be minor issues.

Natural oils and waxes were often used to protect floors and to help keep them dust-free, while retaining most of their permeability. We should maintain and repair our traditional buildings with sympathetic, like-for-like materials. If this approach is deviated from, careful thought should first be given to the likely consequences and whether they can be justified.

If repairs are necessary, try to identify the materials that were used originally and seek to source these from specialist suppliers. This need not be hugely expensive and can save money in the longer term as these materials will be compatible.

If a different floor covering has been specified, is it possible to lay it and still retain the original floor intact underneath? A protective geotextile membrane laid on the existing floor before a new covering is laid may be a good option.

## THE LIMECRETE OPTION

Where a new floor slab is to be created, one option is to use a slab based on lime ('limecrete') which is breathable, rather than one based on cememt (concrete), which is less permeable. A limecrete floor can be designed to meet modern insulation requirements and can incorporate under-floor heating (UFH). It may be possible in some cases to re-lay the original surface on top of the new slab if desired, although this can be difficult to achieve successfully and requires a methodical approach if the character of the floor is not to be altered.

More usually the ground is first excavated and levelled, then a breathable geotextile

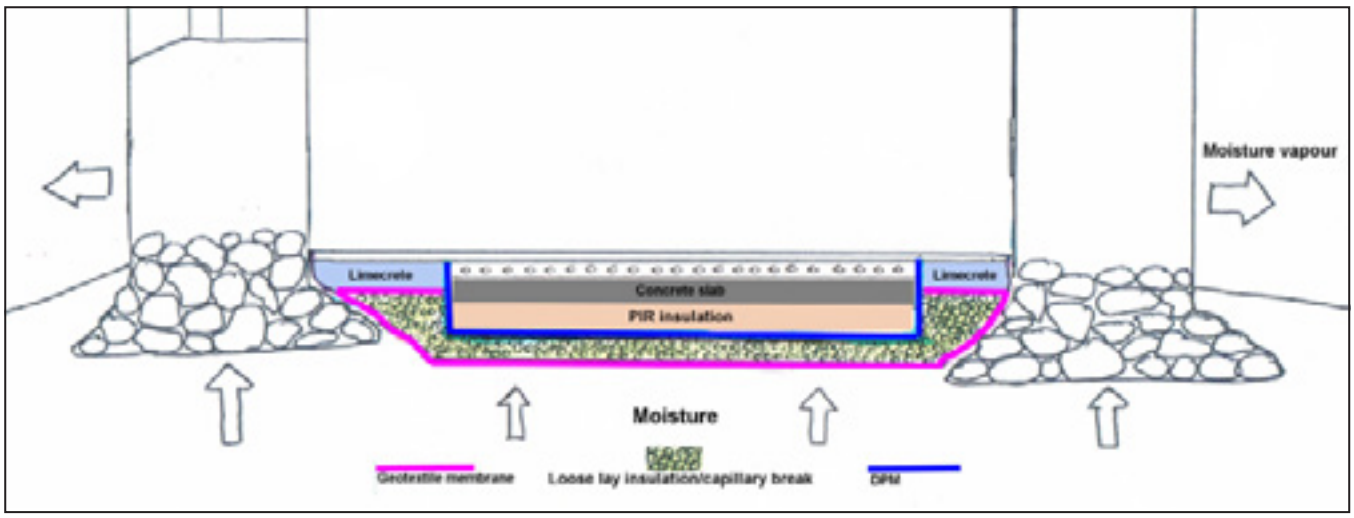
*A limecrete slab being layed over a geotextile separation layer with clay aggregate below: the result is a solid floor that 'breathes' across its entire surface. (Photo: David Blair)*

membrane is laid and the loose-lay insulation is added followed by another layer of geotextile membrane. The limecrete slab is then cast using a mix containing aggregate and hydraulic lime (or lime and a pozzolan). This is usually left for around three weeks before the UFH pipes are fitted and covered with a lime mortar mix or flags are laid.

The two main materials currently used for loose-lay insulation and capillary break are expanded clay aggregate, and recycled glass foam granulate. A typical expanded clay aggregate has a lambda value of 0.1 w/mk. (Lambda values refer to thermal conductivity, measured in watts per square metre of surface area: the lower the value, the better the thermal efficiency.) Glass foam granulate is a is a more expensive option but it has a lambda value of around 0.075–0.08 W $m^{-1}$ $K^{-1}$ so is around 20 per cent more thermally efficient, and it is more structurally stable as it requires compaction.

It may even be considered appropriate to opt for a combination of impermeable and permeable flooring. A hybrid floor is an option where a modern floor is constructed in the centre of the room with a trench between the concrete floor and the surrounding walls (see diagram). This trench is filled with a build-up of limecrete to a depth suitable for the foundations. This provides the capillary break required, allowing the substrate to breathe and preventing the footings from drawing trapped moisture into the walls. This type of floor is becoming increasingly popular. The reasons for choosing this option would be to get the necessary u-values associated with Building Regulations and underfloor heating without increasing the risk to the integrity of the structure.

If you choose to create a modern floor with a slab cast over conventional insulation bats, it is important to choose the insulation carefully. There have been reports of some types of insulation compressing over a number of years, allowing the floor to drop and reducing its insulation value. Make enquiries on the potential long-term performance of your chosen materials before fitting.




*A hybrid floor design with a modern slab isolated from the walls by a vapour permeable limecrete perimeter strip*

*A hybrid floor being laid with shuttering around the perimeter*

## SELECTING THE BEST OPTION

There are many options available to specifiers of solid floors in traditional buildings. Some options work better than others and some might cause irreversible damage or loss of historic fabric. It is important to appraise the individual building and make an informed decision on which build-up is most appropriate.

Whether a new concrete slab is to be constructed or a traditional earth floor is to be retained, damp problems must be dealt with first, and there are a number of other key issues to be considered before deciding on the best solution:

**Is it necessary to dig up the floor?** It might not be desirable aesthetically, practically or legally. Can the floor be repaired rather than excavated?

**Is the floor of architectural/historic interest?** Removing or disturbing an original feature can damage the character and historic record of a building as well as its financial value.

**Is the building listed?** Always check that the building isn't listed and apply for listed building consent if required.

**Is the building in a Radon area?** It is very likely that a DPM will have to be included if Radon is present. The potential adverse effects of a DPM barrier can be largely negated by the introduction of loose-lay insulating aggregate beneath (such as lightweight expanded clay or glass foam granulate).

**Is the work reversible?** Fashions come and go and what the current owner considers an essential modernisation or improvement may be thought of as undesirable in years to come. Is it possible to carry out the work in a way that minimises damage to the original fabric, and can it be undone at a later date?

**If a new solid floor is required, how should it be detailed?** Options include a modern slab, a traditional earth floor, a limecrete floor, and various hybrids. Instead of a DPM a capillary break can be created by introducing a layer of insulating lightweight clay aggregate or recycled glass foam granulate. One danger associated with limecrete floors is the potential need to excavate to a greater depth than the foundations. This can destabilise the building, so great care should be taken to establish how deep the foundations are before selecting the floor type. Two or three test pits by the walls could be dug to allow a plan to be formulated.

**How should the floor be finished?** If a vapour permeable solution is chosen then it is important to note that the whole of the floor should conform to this, including any adhesive or covering employed. For example, a ceramic tile, cementitious adhesive or rubber carpet underlay will all create a barrier to permeability and should be avoided unless used where a DPM is appropriate.

Different materials have significantly different environmental impacts. If sustainability is high on the list of priorities then consideration should be given to competing issues. Should the benefit of improved thermal performance and lower energy consumption override the benefit of a more sympathetic construction approach which is less damaging to historic walls?

Do not necessarily take the view of just one supplier and one approach, there are likely to be many different opinions on what is the best option. Choosing the wrong one might lead to knock-on effects that could adversely affect the building.

New limecrete flooring methods and materials continue to be developed, and the depth of excavation required is being reduced while maintaining capillary break. Some of these new ideas could also radically reduce installation time.

### Recommended Reading

*Energy Efficiency and Historic Buildings: Insulating Solid Ground Floors*, English Heritage, London, 2012 (www.english-heritage.org.uk)

*Fabric Improvements for Energy Efficiency in Traditional Buildings*, Historic Scotland, Edinburgh, 2012 (www.historic-scotland.gov.uk/fabric_improvements.pdf)

*Limecrete: The Vapour Permeable Solid Floor* (includes a method statement for laying a limecrete floor), Mike Wye & Associates Ltd (http://limecrete.net/index.htm)

A Wright, *Care and Repair of Old Floors*, SPAB Technical Pamphlet 15, London, 1999

**PAUL WATTS is the marketing manager of Mike Wye & Associates Ltd and GILLIAN TESH is a director of the company. Mike Wye & Associates Ltd is a specialist manufacturer, supplier and installer of traditional materials.**