JUPITER

Proposal for the supply and installation of a new underfloor heating system at 10 Gloucester Gate

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Introduction

Over the years Jupiter Heating Systems Ltd have developed an underfloor heating system that has been used extensively in churches throughout the UK and central Europe.

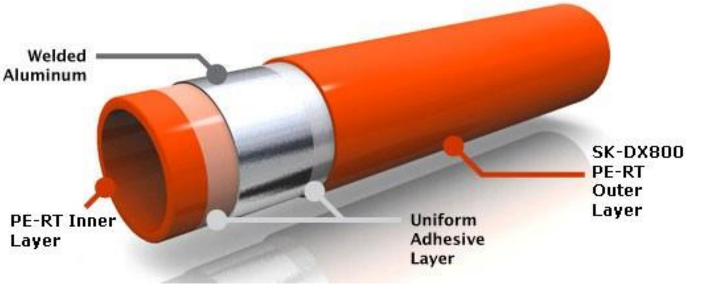
The solutions developed revolve around the concept of removing wet trades which are generally considered unsuitable and harmful to old, historic buildings.

Jupiter took two important factors into consideration when looking at installations within old buildings; maximum heat output and stable substrates. In all cases maximum heat output is a priority. Substrates are a more complex matter and is dependant on the existing floor structure we are presented with.

Employed technology

Jupiter have developed panel based heating systems manufactured from EPS as well as recycled wood fibre. Rather than using screed we developed am interlocking ceramic tile system called the Screed Replacement Tile (SRT). Rather than using concrete we create floor structures using recycled product s such as TechnoPor or granulated slate. All of these individual products have been combined and proven to provide a stable and incredibly strong platform on which to install a suitable floor finish. We have not experienced a single broken tile or stone slab as a result of our system underneath failing.

Screed Replacement Tile (SRT)



Preferred underfloor heating multi layer pipe.

Since being founded in 1996 we have always used German manufactured PE/RT pipe which has a guarantee of 10 years and a design life of 200 years. This is a standard warranty provided by pipe manufacturers in Germany.

Existing floor at 10 Gloucester Gate

The existing floors at 10 Gloucester Gate seem to a combination of solid and suspended floors. This is made up as follows.

Existing basement floor deemed to be solid.

All upper floors deemed to be original suspended floors with the exception of the ground floor entrance which appears to be (and generally are) solid concrete.

Proposed installation procedure

As the final floor finish in the lower ground floor is specified as large format porcelain tiles we would incorporate our IDEAL EPS system and Screed replacement Tile system. The existing floor is being completely removed and therefore additional, primary insulation will need to be added to the above mentioned construction in order to meet Building Regulations.

Photo showing Screed Replacement Tile being prepared for installation over underfloor heating system.

The Screed Replacement Tile system is a floating floor and uses adhesive with minimal water content which unlike a heavy traditional screed doesn't introduce unwanted water into the building.

Final stone floor being installed directly on Screed Replacement Tile at New Bodleian Library, Oxford.

With the upper floors we proposed to install the JUPITER IDEAL ECO system. Being a wood fibre based heating element it is particularly suitable for historic buildings and is sympathetic to the exiting materials. It also provides significant acoustic qualities which will be welcomed by the occupant.

The heating panels themselves are installed between the existing joists by resting them on prepositioned ply sheet which in turn are fixed to joist mounted battens.

Detail showing ply installed between joists of Grade 1 listed building. Joists made level with timber furrings

Being installed between the joists requires that the underfloor heating pipework has to cross the joists occasionally. This is done using a 16mm router set to a depth of 20mm.

With typical 400 centre joists we are able to install 3 pipes between the joists and therefore only have to provide a pipe slot every other joist.

Rear Examples of IDEAL EPS (left) and IDEAL ECO (right) installed within existing joists.

Where heat loss outweighs output from the underfloor system, supplementary radiant heating panels can be installed within the wall and fed by same circuit as floor system.

The are many benefits for installing the JUPITER underfloor heating system – some of which are listed below.

Dry construction – no wet trades or long screed drying times.
Response time – low thermal mass and therefore heats and cools far quicker than screed systems.
High output – 150 W/m² versus traditional screed system with a 80 W/m² output (with stone floor).
Strength – 5 kN point load – suitable for high loads such as cherry pickers etc.
Minimal expansion – unlike heated screed the Screed Replacement Tile system is a fired, inert system.
Movement joints – no movement joints required up to 450m².
Warranty –insurance backed guarantee against floor finish failing for 10 years.

Detail showing stainless steel drip tray under manifold. Prerequisite for Grosvenor Estate projects.

Construction ID – EPS-40G

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Carpet / tiles / timber / laminates / synthetics

Screed Replacement Tile

System IDEAL EPS 240 kPa

4,0 kN/m²

1 Carpet, tile, timber, laminates, synthetics

2 Screed Replacement Tile 20mm

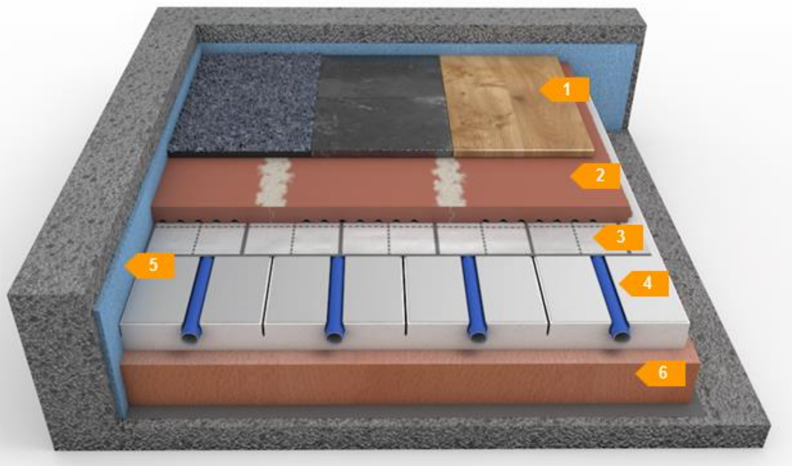
3 JUPITER System foil

4 JUPITER IDEAL EPS 30mm

5 Perimeter insulation

6 Primary insulation i.e. Kingspan

Construction height 100-150mm



Technical Data — Construction suitable for floors with significant heat loss below

Construction height*	mm	100-150	Height without floor finish
Weight*	kg/m²	42-44	Weight without floor finish
Thermal resistance R**	m²K/W	3,379	
Heat exchange coefficient	W/m²K	0,17-0,21	
Uniform Distributed Load (UDL)	kN/m²	4,0	
Point load (≥ 20cm²)	kN	3,0	
Impact sound reduction	dB	-	
Area of application Ground floors or floors located above unheated rooms such as garages, basements etc. 	* Based on 50-100mm Kingspan Kooltherm K3 ** Based on Kingspan Kooltherm K3 and the additional properties of the JUPITER IDEAL 30mm element. The resistance does not include for thermal resistance offered by the ground conditions. For upper floor installation see construction EPS-30U.		
Installation information Working in conjunction with Kingspan	Substrate must be solid, level and flat so that the heating elements can lie flat. Tolerance required as per DIN 18202 table 3, group 4. Installation environment must be minimum +5°C SRT material format: 400mm x 180mm x 20mm Construction tested with Kingspan Kooltherm K3 ≤ 100mm		

Construction ID – ECO-BJ2 Part E

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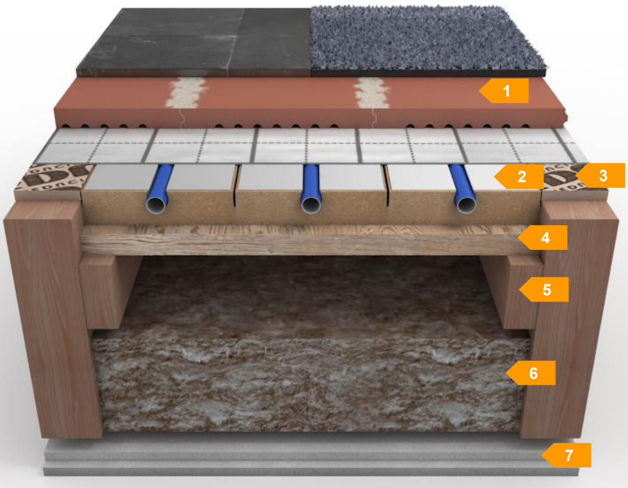
All floor finishes

Screed Replacement Tile
System IDEAL ECO 150 kPa

5,0 kN/m²

1	Screed Replacement Tile	20mm
2	JUPITER IDEAL ECO	30mm
3	Redupax acoustic strip	9mm
4	Supporting ply	
5	Supporting batten	
6	Mineral wool insulation*	
7	Acoustic ceiling detail**	
	Construction height	**29mm**



Technical Data | **Construction suitable for floors between rooms of equal temperature**

Construction height	mm	29	System height based on S.R.T. and Redupax strip thickness
Weight	kg/m²	46	Weight without floor finish
Thermal resistance R	m²K/W	0,86	Part L compliant for floors above heated rooms
Heat exchange coefficient	W/m²K	0,97	
Uniform Distributed Load (UDL)***	kN/m²	5,0	
Point load (≥ 20cm²)***	kN	5,0	
Sound reduction	dB	Impact *LnTw* 44 dB Airborne *DnTw + Ctr 55* dB	
Area of application Floors with rooms of equal temperature above & below Rmin=0,75 m²K/W 20°C 20°C	This construction is valid for floor constructions located above uninsulated or unheated space ***Joist integrity dependent		
Specific installation requirements	When installed the Screed Replacement Tiles may follow any undulation that occurs from the joists. This may need to be taken out with the use of a thin levelling compound. Aluminium diffuser plates should be flush with top of Redupax strip. * Min. 100 kg/m² mineral wood ** Typical MF suspended ceiling detail Part E pass requirements Impact *LnTw ≤ 64dB*, Airborne *DnTw + Ctr ≥43dB*		

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Installation time

The time frame for the installation of the, additional insulation, heating panels and the S.R.T. should take no longer than 4 working weeks. Jupiter are responsible for the installation up to and including the manifold. All electrical work should be carried out by a qualified electrical engineer. Final connections between the UFH manifolds and the heat source should be carried out by the site heating engineer.

Floor finishes can be installed on the S.R.T. after 36 hours. The system does not require a heating up protocol though natural finishes such as timber and natural stone may require acclimatisation.

Additional information

To illustrate our past experience and the extent to which we vigorously test our solutions we have included the following.

Full scale deflection test – undertaken by the BRE to demonstrate the deflection capabilities of the S.R.T. system.

Case studies included.

Pitshill House – Grade II listed house

Dene Hall – Grade I listed house

West Court

King George Street – Grade II listed house

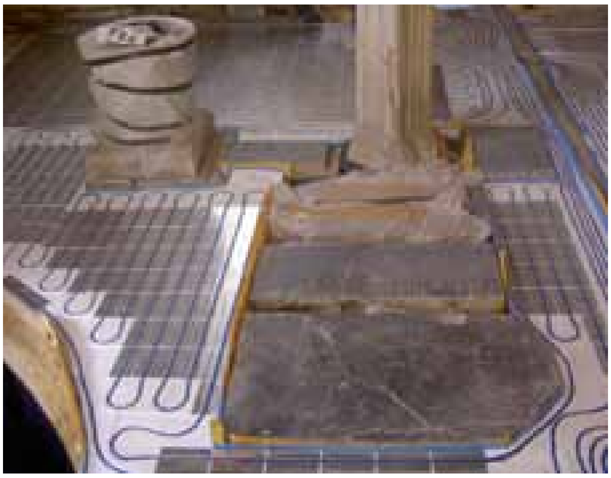
Other accompanying information

Energy Efficiency and Historic Buildings - English Heritage Document

ENGLISH HERITAGE

Energy Efficiency and Historic Buildings

Insulating solid ground floors



This guidance note is one of a series which explain ways of improving the energy efficiency of roofs, walls and floors in historic buildings. The full range of guidance is available from the English Heritage website:

www.english-heritage.org.uk/partL

Introduction to the series

This guidance note is one of a series of thirteen documents providing advice on the principles, risks, materials and methods for improving the energy efficiency of various building elements such as roofs, walls and floors in older buildings. The complete series includes the following publications:

ROOFS

Insulating pitched roofs at rafter level/warm roofs
Insulating pitched roofs at ceiling level/cold roofs
Insulating flat roofs
Insulating thatched roofs
Open fires, chimneys and flues
Insulating dormer windows

WALLS

Insulating timber framed walls
Insulating solid walls
Early cavity walls

WINDOWS AND DOORS

Draught-proofing windows and doors
Secondary glazing

FLOORS

Insulation of suspended ground floors
Insulating solid ground floors

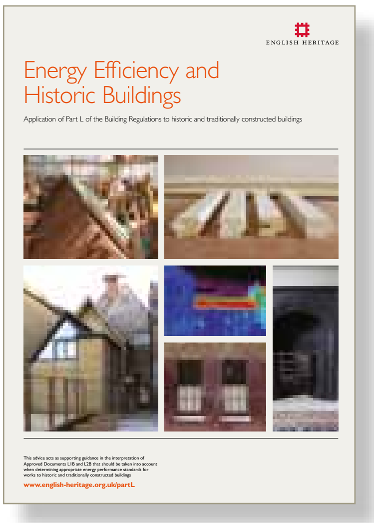
All these documents can be downloaded free from:
www.english-heritage.org.uk/partL

This series of guidance documents provide more detailed information to support our principle publication:

Energy Efficiency and Historic Buildings: Application of Part L of the Building Regulations to historic and traditionally constructed buildings

This publication has been produced to help prevent conflicts between the energy efficiency requirements in Part L of the Building Regulations and the conservation of historic and traditionally constructed buildings. Much of the advice is also relevant where thermal upgrading is planned without the specific need to comply with these regulations.

The advice acts a ‘second tier’ supporting guidance in the interpretation of the Building Regulations that should be taken into account when determining appropriate energy performance standards for works to historic buildings.



CONSERVATION PLANNING

Before contemplating measures to enhance the thermal performance of a historic building it is important to assess the building and its users to understand:

- the heritage values (significance) of the building
- the construction and condition of the building fabric and building services
- the existing hygrothermal behaviour of the building
- the likely effectiveness and value for money of measures to improve energy performance
- the impact of the measures on heritage values
- the technical risks associated with the measures

This will help to identify the measures best suited to an individual building or household, taking behaviour into consideration as well as the building envelope and services

TECHNICAL RISKS POSED BY THERMAL UPGRADING OF OLDER BUILDINGS

Altering the thermal performance of older buildings is not without risks. The most significant risk is that of creating condensation which can be on the surface of a building component or between layers of the building fabric, which is referred to as 'interstitial condensation'. Condensation can give rise to health problems for occupants as it can lead to mould forming and it can also damage the building fabric through decay. Avoiding the risk of condensation can be complex as a wide range of variables come into play.

Where advice is given in this series of guidance notes on adding insulation into existing permeable construction we generally consider that insulation which has hygroscopic properties is used as this offers a beneficial 'buffering' effect during fluctuations in temperature and vapour pressure, thus reducing the risk of surface and interstitial condensation occurring. However, high levels of humidity can still pose problems even when the insulation is hygroscopic. Insulation materials with low permeability are not entirely incompatible with older construction but careful thought needs to be given to reducing levels of water vapour moving through such construction either by means of ventilated cavities or through vapour control layers.

The movement of water vapour through parts of the construction is a key issue when considering thermal upgrading but many other factors need to be considered to arrive at an optimum solution such as heating regimes and the orientation and exposure of the particular building.

More research is needed to help us fully understand the passage of moisture through buildings and how certain forms of construction and materials can mitigate these risks. For older buildings though there is no 'one size fits all' solution, each building needs to be considered and an optimum solution devised.

TECHNICAL ILLUSTRATIONS GENERALLY

The technical drawings included in this guidance document are diagrammatic only and are used to illustrate general principles. They are not intended to be used as drawings for purposes of construction.

Older buildings need to be evaluated individually to assess the most suitable form of construction based on a wide variety of possible variables.

English Heritage does not accept liability for loss or damage arising from the use of this information.

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Introduction

This guidance note provides advice on the methods, materials and risks involved with insulating solid ground floors. The energy saving resulting from insulating solid ground floors can in many cases be of marginal benefit when the cost and disruption to the building fabric are considered. Insulating other building elements is likely to produce greater benefits in energy efficiency for significantly less cost. This is partly because a typical solid floor already provides a degree of insulation, but mainly because the ground beneath maintains a stable temperature of around 10 degrees C. However, where an existing floor is being taken up, replaced or repaired, then it can be worth making use of the opportunity to improve thermal performance.

Solid ground floors can be a significant part of the history and character of a building, so taking up floors and excavating below to install insulation can be extremely damaging to valuable historic fabric. Even where the floor finish is of no particular historic value, any alterations to the floor structure beneath need to take account of potential buried historic features and archaeology. This can, for instance, be particularly significant in churches. All such work will require consent if the property is listed.

Insulating solid ground floors will often alter the performance characteristics of the floor structure. There can be a significant risk of exacerbating any existing moisture-related problems, or of causing problems in adjacent construction, such as diverting moisture up into the outside walls.

Impermeable damp proof membranes and materials which are highly resistant to the passage of water vapour are often not compatible with the traditional construction techniques used in older buildings.

01 Solid ground floor construction

The earliest floors were 'earth' floors formed usually of a locally available compacted material such as earth, clay, gravel or chalk material (about 50 -100 mm thickness). The finished surface was then often covered with rushes and herbs to reduce the amount of dust.

Until the development of suspended timber ground floors in the early 18th century, solid floors had been the dominant form of construction. By the beginning of the 20th century, the ground floors of most houses comprised boarded suspended timber floors on sleeper walls, with solid floors of quarry tiles laid directly on the earth or a bed of ashes mainly restricted to basements, kitchens and outhouses. However, between the wars the wider availability of Portland cement enabled reinforced concrete ground floors to gradually replace suspended timber floors, and they have since become the standard form of modern ground floor construction.

TYPES OF SOLID FLOOR CONSTRUCTION

In all types of buildings a variety of flooring materials have been used to give a more robust and hard wearing surface. Typically these were hard materials either bedded directly on well rammed earth or chalk, on a layer of sand or clay, all on a bed of well compacted rubble hardcore,.

Plain stone flags, which may be very variable in thickness, were commonplace from the medieval period to the early 19th century, and are usually of historical significance. They were normally laid directly on earth or sand, and butt jointed. Mortar pointing is usually a later modification since it was not until the late 18th century that mortars were developed which could survive prolonged exposure to both wear and ground moisture.

In the 13th century plain clay and decorative floor tiles began to be used as a floor finish. These tiles were mostly glazed, and varied in size from about 100mm to 200mm square. They were laid butt-jointed on a bed of lime mortar. Decorative tiles were either pressed and decorated with a clay inlay of differing colour (termed encaustic) or painted and sealed. Quarry tiles made of clay moulded in presses, by hand or machine, and then fired in a kiln were common from the 18th century. The Gothic Revival in the Victorian period saw mass-produced reproductions of the intricately patterned medieval encaustic tiles.

By the 14th century brick floors were being manufactured and imported. Large tiles of clay were also being used for flooring, such as 'pamments' and flooring 'pantiles'.

01 By the 14th century brick floors were being laid © English Heritage NMR

Mosaic tiled floors comprise a mortar base laid on gravel into which coloured tesserae (small squares either cut or knapped from large slabs of marble or stone) set while the mortar was wet. Terrazzo floors are small fragments of marble and stone mixed with stucco or mortar and laid on a screed of weak concrete, the surface being ground and polished when set.

The availability of materials and local tradition resulted in two related flooring materials, lime and gypsum, appearing in both lowly and high status buildings from the 16th century to the19th century. The use of plaster on ground floors was usually limited to passages and was typically laid direct onto rammed earth. The inclusion of brick dust, animal blood, ash and other materials imparted durability, colour and finish. Composite lime concrete floors, containing gravel, chalk, ironstone or other stone chips as aggregate, have been found in excavations of medieval churches, and were probably widespread.

The discovery of cement in the early 19th century and the introduction of Portland cement and reinforced concrete in the 1850s revolutionised construction methods for solid ground floors, especially those bearing heavy loads. This led to the use of a variety of aggregates to produce joint-less floors such as:

- Granolithic concrete –hard-wearing in situ flooring made up of cement, sand and granite aggregate.
- Magnesium oxychloride - hard-wearing in situ flooring made up of calcined magnesite, various fillers and magnesium chloride. Also referred to as a magnesite floor. These were popular in the 1930s to 1950s. Magnesite is easy to work with and can be sculpted and moulded for use on stairs and around hard-to-tile areas.
- Calcium sulphate – finely ground catalysed anhydrite with an aggregate of crushed rock anhydrite with anti-static attributes.

02 Issues to consider before installing insulation

It is important to understand the type of construction one is dealing with before making changes particularly if these are irreversible. This means the performance and materials of not just the solid floor but also the adjacent walls and local ground conditions.

CONSTRUCTION

Many older buildings will have been subjected to alterations over their lifetime including changes to their internal layout and local floor finishes, and can therefore have ground floors of several different types of construction. The differing performance characteristics of these floors and materials need to be assessed both individually and together to understand how the ground floor is performing.

MOVEMENT OF MOISTURE

Solid floors of traditional construction were normally bedded directly on the earth or on permeable fills or mortars with no damp proof membrane, and consequently have different physical characteristics to modern solid concrete floors. These floors are able to absorb and evaporate moisture from the whole surface area without detriment to the materials. Interfering with this quality can easily drive moisture into vulnerable adjacent construction.

THE IMPORTANCE OF 'BREATHING' PERFORMANCE

Most traditional buildings are made of permeable materials, and do not incorporate the barriers to external moisture such as cavities, rain-screens, damp-proof courses, vapour barriers and membranes which are all standard in modern construction. As a result, the permeable fabric in historic structures tends to absorb more moisture, which is then released by internal and external evaporation. When traditional buildings are working as they were designed to, the evaporation will keep dampness levels in the building fabric below the levels at which decay can start to develop. This is often colloquially referred to as a 'breathing' building.

If properly maintained a 'breathing' building has definite advantages over a modern impermeable building. Permeable materials such as lime and/or earth based mortars, renders, plasters and limewash act as a buffer for environmental moisture, absorbing it from the air when humidity is high, and releasing it when the air is dry. Modern construction relies on mechanical extraction to remove water vapour formed by the activities of occupants.

As traditional buildings need to 'breathe', the use of vapour barriers and many materials commonly found in modern buildings must be avoided when making improvements to energy efficiency, as these materials can trap and hold moisture and create problems for the building. The use of modern materials, if essential, needs to be based upon an informed analysis where the implications of their inclusion and the risk of problems are fully understood.

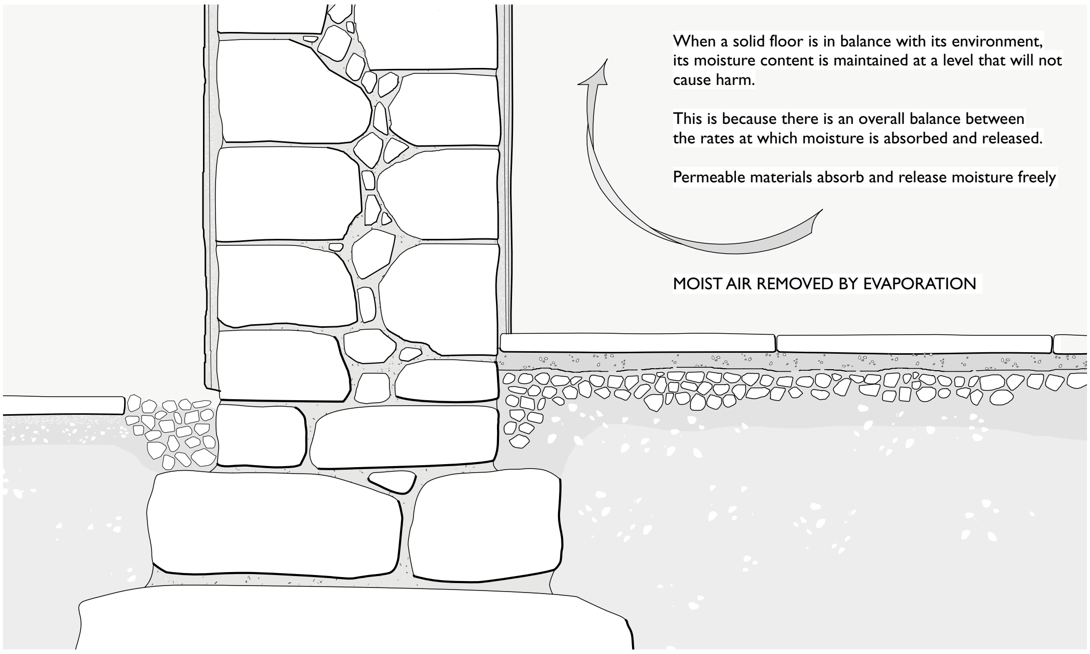
It is also important that buildings are well maintained, otherwise improvements made in energy efficiency will be cancelled out by the problems associated with water ingress and/or excessive draughts.

The commonest source of dampness in solid floors is moisture rising from the sub-soil, taken up into the floor by capillary forces or the presence of hygroscopic (water attracting) materials such as salts. The presence of salts in the floor will affect how moisture is transferred through the fabric of a building, including floors and walls.

The other principal source of dampness is condensation. This occurs at times of greatest temperature difference between the floor and the air. For example, in warm and damp conditions in spring and summer when the ground is cold, moisture is deposited on the surface of the floor. Alternatively, in winter when the ground is warm and the outside air cold, condensation can occur beneath the floor layer.

Analysis has shown that in buildings with solid ground floors the moisture content of the floor alone can be more than half the total moisture content of the structure overall. However, as long as the moisture ingress and evaporation are in balance this is tolerable, and is unlikely to cause damage to the building. Where a solid ground floor is in equilibrium with its environment, the moisture distribution within the floor will be virtually uniform at all points.

UNINSULATED HISTORIC FLOOR IN EQUILIBRIUM WITH IT'S ENVIRONMENT



02 A permeable solid floor can be in equilibrium with its environment when moisture is able to easily evaporate uniformly with an adequate amount of ventilation.

The generally high level of moisture present in traditional solid ground floors normally requires evaporation from the entire floor surface in order to maintain the necessary equilibrium. Any impervious material laid on a solid floor, such as rubber–backed mats, carpets or solvent-based waxes, will impede the movement of this moisture and cause localised concentration. The restriction of evaporation of moisture from the floor encourages the build up of salts and may lead to the decay of the flooring material. These problems can be severely exacerbated by localised cement patching and pointing.

It is important that this ‘breathing’ performance is maintained whenever insulation is introduced, in order to avoid creating risks for both the building and the occupants.

GROUND INSULATION QUALITIES

The pattern of heat loss through floors in contact with the ground is more complicated than that through the above-ground building fabric. Heat loss will be significantly greater through areas of the floor near external walls than through the centre of the floor, and total heat loss will depend upon the ratio of the exposed perimeter of the floor to both its overall area and the thickness and composition of the adjacent walls.

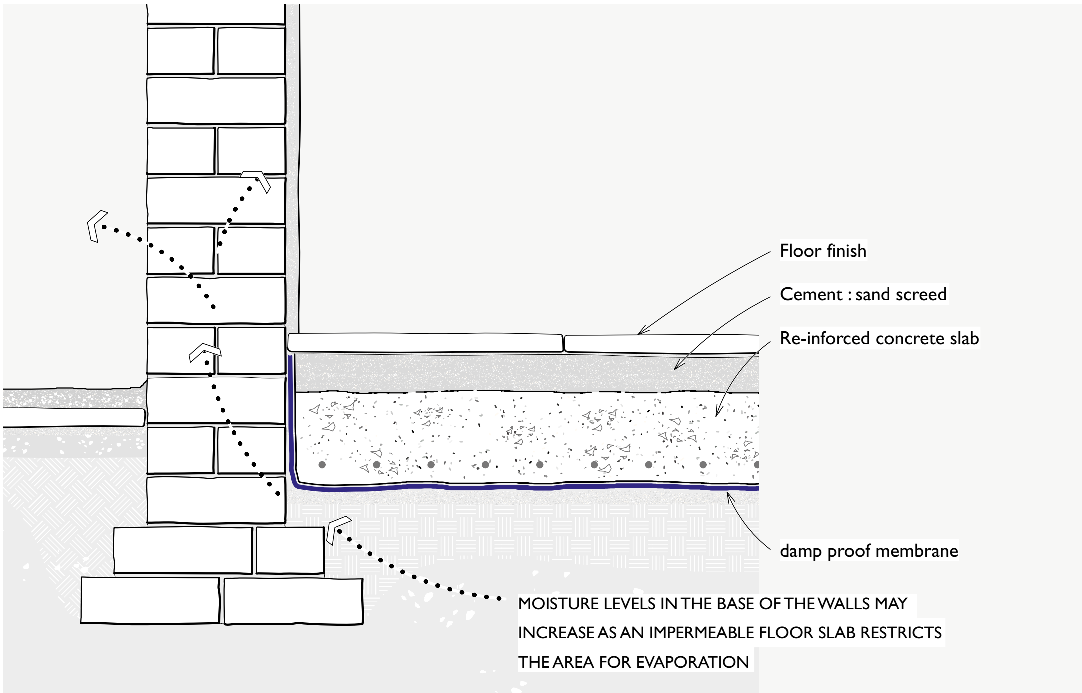
When calculating heat loss to the ground it is also important to bear in mind that the ground itself maintains a surprisingly stable temperature of around 10 degrees C. During the heating season the temperature difference between the internal space and the ground is therefore typically smaller than that between the internal space and the outside air. For example, on a cold winter day one could reasonably expect a 20 degree C temperature difference in conditions either side of a roof or wall construction, but perhaps only 10 degrees between internal conditions and the ground.

The thermal mass of an element is a measure of its capacity to store and regulate internal heat. Solid ground floors have a very high thermal capacity, which means they take a long time to absorb heat, but then release it slowly as the surroundings cool down. As a result they are very effective in maintaining a steady temperature in the internal environment. In addition, a solid ground floor behind south facing windows can take in a great deal of solar gain during the day, limiting overheating in the internal air, but will then release it slowly at night. Care is needed to ensure that the benefits of thermal mass are retained when insulation and other improvements are made to existing floors, or the presumed advantages of added insulation may not live up to expectations.

DAMP-PROOF MEMBRANES AND SOLID FLOORS

Since the Second World War a large number of suspended timber and solid ground floors in traditional buildings have been replaced with modern concrete ground-bearing floors. These well intentioned repairs were often undertaken to address problems of dampness, and utilised the standard practice in the construction of new buildings of incorporating a damp proof membrane within the floor thickness.

SUSPENDED TIMBER FLOOR REPLACED WITH UNINSULATED CONCRETE SLAB & DPM



03 Many suspended timber floors have been removed in the past and replaced with un-insulated concrete slabs installed over a damp proof membrane. This can in some cases drive moisture into the walls that would otherwise have permeated through the floor and evaporated in the ventilated sub-floor area.

Significant historic fabric is often lost or damaged when this type of solid floor is introduced in traditional buildings. The relaying of a floor on a damp-proof membrane restricts the amount of moisture which can evaporate through the floor. The ground moisture is often displaced to the base of the walls where it can cause rising damp instead.

Even without a damp-proof membrane, a dense concrete floor, or even a solid floor made of a thick layer of high strength hydraulic lime, will allow very little moisture movement, and will also effectively function as a damp-proof construction in itself.

Because of these risks, careful consideration should be given to adding floor insulation where a damp-proof membrane is an integral part of the system, when there has been no membrane used in the floor in the past.

SALTS

Taking up and relaying an old brick, stone or tiled floor on a new concrete sub-floor with a damp-proof membrane can cause salts within the old floor materials to migrate to the surface resulting in white efflorescence on the floor surface. These salts in turn can absorb moisture from the air and create a damp floor purely by their hygroscopic action. They have an affinity for water, and readily absorb moisture from the air or from other substances. They try to achieve equilibrium with their surroundings by taking up or releasing moisture. Changing moisture levels occurring with fluctuations in heating can result in the re-crystallisation of the salts which exacerbates problems of damp. The crystal growth in the pores can also severely erode the original materials.

04 Salts appearing on the surface of a solid floor that has been very damp © Janice Gooch

Salts are commonly found around fireplaces and chimney breasts, where they originated as by-products of combustion. They are present in the ground and are sometimes introduced when cements are used for repairs or they may also result from the previous use of the building, particularly if it was agricultural or industrial, or from the use of chemicals such as caustic soda to remove paint. Salts may also be present in the original building materials from new, for example in stone or aggregates from a marine environment.

DAMP CONDITIONS

A solid ground floor in a traditional building which allows the movement of moisture and has a stable moisture content will be in equilibrium with its environment. Damp conditions occur when excessive amounts of moisture are trying to escape through the floor. In such cases an investigation into the cause of this high moisture level is strongly recommended, as action taken to cure the problem at source is usually preferable to just treating the symptoms. In many cases the cause is directly related to maintenance defects, changes in the surrounding environment, or interventions that have undermined the 'breathing' potential of the floor and walls, rather than a failure of the original design and construction.

Particularly high levels of moisture in solid floors may be due to:

- failure of gutters and down-pipes
- damaged and/or blocked drains
- raised external ground levels or inadequate falls away from the building
- leaks from water supply or heating pipes
- movement of salts
- condensation
- the addition of impermeable floor coverings

When investigating high levels of moisture in a floor it is useful to measure the moisture content of both the flooring, and the layer on which it rests. Samples from the bedding layer and at a depth of 150 – 200mm below on the same vertical line can show significant differences which will help to identify the likely source.

Before making any improvements it is important to understand how solid floor buildings 'manage' the movement of water, in vapour and liquid form. This is not only complex in itself but is also affected by changes in salt concentrations, which can significantly affect how moisture is transferred.

Most insulation systems are designed and developed to limit heat loss and to avoid interstitial condensation from water vapour generated internally. They do not take account of how they affect the movement of water and salts in the abutting walls and can lead to:

- exacerbation of existing moisture problems;
- creating new problems, such as the displacement of damp and salts and the decay of timbers in contact with the walls;
- creating health risks for the occupants through mould growth.

Permeable floors and walls may have been damp for a long time, and it can take some time for them to dry out sufficiently and return to equilibrium conditions. This cannot be achieved overnight, and may take months or even years to reach an acceptable level. The selection and the design of any added insulation must take account of this drying out process, both before and after installation, and the presence of residual damp and salts.

COST-EFFECTIVENESS

The level of comfort in a building is of key importance to the occupants, and solid ground floors can feel cold as a result of direct conduction and possibly low-level draughts. However, the actual amount of heat lost through the floor may actually be significantly less than for other elements of the building as a result of both the buffering effect of the thermal mass and its insulating effect. The insulation of a solid ground floor can also be expensive and disruptive, so unless it needs to be taken up and re-laid for another reason, it may actually be more cost-effective to concentrate on interventions which give a greater benefit.

03 Issues to consider when insulating solid ground floors

HISTORIC FLOORS

It is a key principle of building conservation that materials constituting the original fabric of the building are maintained in use for as long as possible, as they are vital parts of the building's significance and character. The floors of old buildings are often worn, discoloured and out of true level, but conservative repair of localised damage is almost always preferable to wholesale replacement. As a general rule, the excavation and replacement of significant solid ground floors should be avoided unless it is necessary to remedy a destructive defect.

RECORDING

Where a floor is to be excavated, the archaeology of the floor should be recorded. Even if the floor is of a modern material, important information may be found below it that adds significantly to the history of the building.

If the existing floor material is to be lifted, individual floor slabs or tiles should be replaced in their original locations. A plan recording the setting out of the floor material and corresponding durable labelling of the floor components is vital for accurate relaying. A photographic record of the floor surface may assist with this process. For historically significant or complex floors there are a range of sophisticated mapping techniques available from specialists, such as rectified photography, which can help to provide accurate measurements and survey records.

DEPTH OF FOUNDATIONS

The excavation of ground floors can risk undermining the structural stability of adjacent walls and/or chimney breasts that have shallow footings. This is particularly the case with stone flagged floors with variable depth stones, as some can be surprisingly thick in places.

To assess the ability of the footings to accept additional pressure, and to avoid undermining the footings, trial pits need may need to be dug to find out the actual depth of original footings in relation to the proposed level of any new floor construction.

REMOVAL OF EXISTING FLOOR MATERIAL

To enable the re-use of the historic floor material on the new floor structure, the lifting of the floor material should be undertaken with great care to minimise the risk of damage. A designated storage area outside the room where the works are taking place should be provided to avoid any damage to the materials before re-fixing. Best practice for valuable floors would allow then to be laid out temporarily and stored in their correct pattern. All items should be carefully labelled to allow for re-instatement: if any repairs are to be carried out to individual units, the labelling system needs to be designed to endure this process, whilst still being reversible on completion.

UNDER-FLOOR HEATING

Low pressure hot water under-floor heating is increasingly popular, and is now available in a range of forms for installation in solid floors. Where the existing ground floor has already been lost or requires replacement this can be a very appropriate form of heating a historic building as it can make good use of both the large surface area of a complete floor and the thermal mass. Low temperature radiant heat is also gentle on the historic fabric itself, and helps to limit condensation arising from sharp changes in air temperature relative to the fabric.

However, an under-floor heating system will greatly increase the difference between the floor temperature and the ground temperature below, perhaps by as much as 10-15 degrees C. This will significantly increase the potential for heat loss through the floor and the installation of an insulation layer below the heating system should therefore be regarded as an essential part of such a system.

In the design and installation of heating systems in historic buildings, the lifespan of the heating system needs to be considered against that of the building. The typical design lifespan of twenty years for a heating system is very short compared to a building that may already be several centuries old, and the need for further physical intervention in valuable floors within such a short period, with all the potential for further damage that may cause, should be carefully taken into account.

05 The addition a of an insulation layer is an essential part of an under-floor heating system © Jupiter Heating Systems

04 Insulating materials for solid floors

CONVENTIONAL INSULATION MATERIALS

Most insulation materials used for solid floors rely on an impervious damp proof membrane to keep the insulation dry. Insulation materials used for new concrete floors also need to have a high compressive strength so that they can be placed either below the slab itself or below the screed.

This limits the types of insulation material which can normally be used to one of the following:

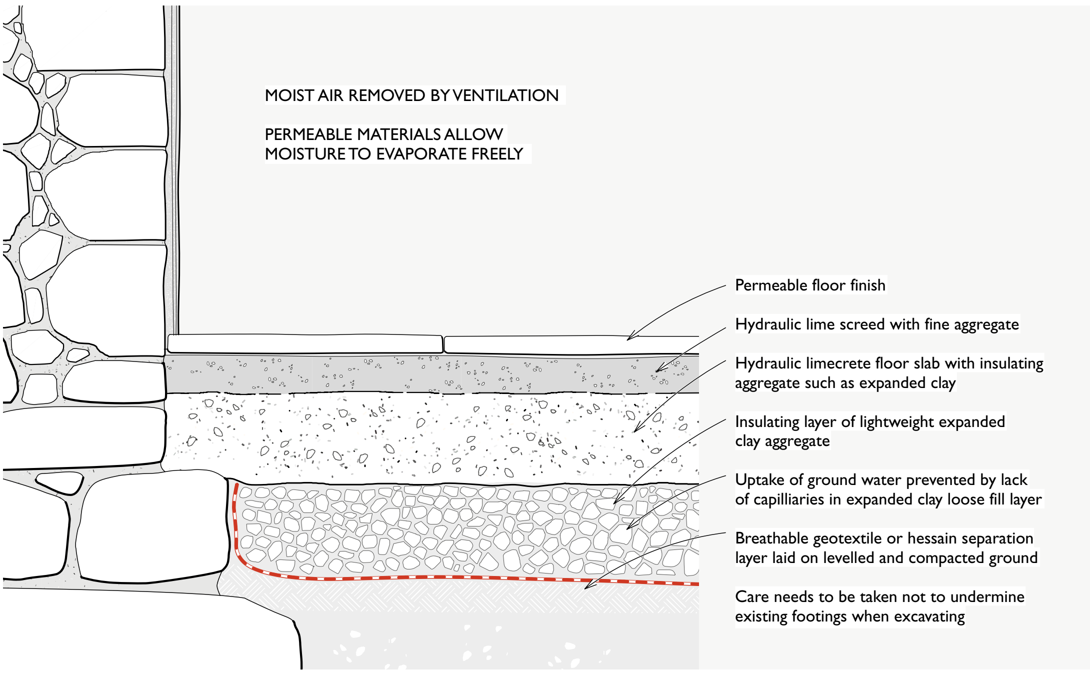
- Foamed glass
- Expanded or extruded polystyrene
- Rigid urethane foam, often foil-faced
- Rigid phenolic foam

All of these materials are virtually impervious to air and moisture and will therefore significantly disrupt the moisture balances within adjacent permeable materials. As previously stated this can be potentially damaging to buildings of traditional construction.

INSULATING LIME CONCRETE

A recently-developed method of insulating solid floors in traditional buildings is based on a designed mixture of natural hydraulic lime binders ('NHL's) and insulating aggregates. The materials chosen have the ability to absorb and emit moisture, and so create 'breathable' insulating floors, thus overcoming many of the disadvantages of impermeable systems. These floors can be laid with or without under-floor heating.

INSULATING LIMECRETE SLAB



06 Where a decision is taken to insulate a historic floor then one option is to provide a permeable insulated floor slab a shown here. Expanded clay is used as the insulant.

A typical installation consists of a build-up of three layers:

- Principal insulating layer – a layer of expanded clay aggregate laid loose, normally over a breathable membrane to prevent the ingress of subsoil particles.
- Insulating lime concrete slab – a layer of insulating aggregate, normally also expanded clay, with hydraulic lime binder.
- Screed - a screed made with a suitable blend of hydraulic lime with a fine aggregate. This layer can be replaced or finished with re-used tiles or stones in order to reinstate a historic floor finish.

07 A hydraulic lime floor being laid
© The Limecrete Company

A typical installation of an insulating lime concrete floor involves the excavation of the ground to the required depth, then levelling and compaction of the ground before installation of the breathable membrane. This need for substantial excavation is the principal disadvantage of this system. Any floor finishes laid on a lime concrete floor should be permeable to retain the movement of moisture vapour through the floor.

Insulating lime concrete floors are generally purpose-designed for each individual situation. The depth of each layer will depend on:

- Floor area and shape
- Substrate type
- Groundwater pressure
- Intended use
- The thermal insulation value required
- Whether under-floor heating is required
- Wall thickness and construction

AMOUNTS OF INSULATION

The Approved Document that accompanies Part L of the Building Regulations for existing dwellings AD LIB (2010), calls for floors to be insulated to achieve a U-value of 0.22 W/m²K.

U-VALUES

U-values measure how quickly energy will pass through one square metre of a barrier when the air temperatures on either side differ by one degree.

U-values are expressed in units of Watts per square metre per degree of temperature difference (W/m²K).

In many cases existing un-insulated floor U-values are already relatively good when compared with wall and roof U-values.

The target U-value of 0.22W m²/K is appropriate subject to other technical constraints, for example depth of footing and adjoining floor levels. A 220mm layer of lightweight expanded clay aggregate loose fill will generally achieve a U-value of 0.45W/ m²K on its own.

The size and shape of the floor (perimeter/area ratio) will, however, affect the overall U-value performance, and thus the depth of insulation required. Individual calculations will need to be prepared for each particular situation.

05 Further information

British Standards Institution 2011, *Code of Practice for control of condensation in buildings* BS 5250, London: British standards Institution

CIBSE, 2006, *Guide A / Environmental Design*, London: CIBSE

Fawcett, J, 1998, *Historic Floors*, Butterworth Heinemann

George, M Geens, A & Littlewood, 2005/6, *Beware the Blanket Approach; Building for a Future* Volume 15 No.3 and 4

Massari, G & I, 1993, *Damp Buildings Old and New*, ICCROM,

Pye, P. & Harrison, H. 1997, *BRE Building Elements, Floors and Flooring*, Building Research Establishment

Rodwell, W, 1989, *Church Archaeology*; English Heritage & Batsford

Stirling, C 2002 *Thermal Insulation: Avoiding risks* (3rd Edition) London: Building Research Establishment

Watt, D & Swallow, P, 1996, *Surveying Historic Buildings*, Donhead,

Wright, A, 1999, *Care and Repair of Old Floors; Technical Pamphlet 15* Society for Protection of Ancient Buildings

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English Heritage is the Government's statutory adviser on the historic environment. English Heritage provides expert advice to the Government about all matters relating to the historic environment and its conservation.

The Conservation Department promotes standards, provides specialist technical services and strategic leadership on all aspects of the repair, maintenance and management of the historic environment and its landscape.

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ENGLISH HERITAGE

Case Study 5 System IDEAL EPS Between Joist Application

Installation of JUPITER IDEAL system between existing joist application

Existing joists battened and lined with ply 30mm below top of joist. IDEAL panels cut to fit tightly between.

Flow and return pipes as well as circuit pipes channelled through joists.

Schotten & Hansen timber floors installed directly over existing floor joists.

Jupiter Edge Zone (EZ) panels used to provide 3 pipes per joist void.

T&G Screed Replacement tiles laid directly on top of System panels (separating foil protects pipes from glue). Tiles act as load bearing surface for final stone floor.

T: 01276 859 066 www.jupiterunderfloorheating.com

Case Study 6 System IDEAL EPS Between Joist Application

RW Armstrong commissioned JUPITER to install the IDEAL System within the existing floor joists of a large private residence on the banks of the river Thames. In order to maximise heat output in conjunction with a ground source heat pump and to provide a stable substrate for natural stone floor finishes the Screed Replacement Tile S.R.T. was specified.

Existing suspended wooden floor removed to expose joists

IDEAL System installed within existing joists. Resting on additional insulation resting on battens and ply supporting sheets.

20mm thick Screed Replacement Tiles installed directly over the existing floor joists on JUPITER System foil.

After 36 hours S.R.T. substrate ready to accept finished floor.