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CPD Article

Published on 12 February 2021 11:37

Flooring Insulation in Ground Floors - Laying a Strong Foundation

Since 1990, Building Regulations have required ground floors to be insulated in order to save energy. This CPD article looks at the factors that need to be considered when addressing ground floor insulation, including: construction techniques, thermal bridging, calculating U-values, and the impact of insulation on a project's design.

Key Learning outcomes

- Understanding the core principles of flooring insulation
- Knowledge of different construction techniques
- How to calculate U-values
- Understanding loading
- Importance of correct insulation material

1.0 Basic principles and floor construction

Ground floors may be classified as ground-bearing – in contact directly or indirectly with the ground – or suspended.

The ground absorbs heat from floors that are close to or in contact with it, mostly around the external floor perimeter where the ground is generally colder. High soil moisture content increases heat absorption. These effects, when combined with the natural temperature gradient in buildings, can lead to an uncomfortable internal environment, condensation at external wall/floor junctions and higher than predicted energy usage. These factors must be taken into account when calculating the insulation requirements for a ground floor.

All other floor types are, by definition, suspended. Here, heat is lost/gained uniformly across the entire surface.

A layer of thermal insulation in the floor construction, continuous with that in the rest of the building envelope, can reduce heat loss. It can also help avoid thermal bridges – breaks in integrity and continuity where the floor meets external or load-bearing internal walls. To minimise the potential thermal bridge, wall and floor insulation should meet or overlap where practicable.

Floor construction

Ground floors are typically constructed from ground-supported concrete slabs, suspended concrete floors (including beam and block systems), or suspended timber floors. (see BRE’s Good Building Guide 28, Part 1, for specific construction details).
A ground floor construction’s primary function is to prevent the transfer of moisture from the surrounding ground into the interior of the building. Damp-proof membranes (dpm) should be continuous with any vertical and horizontal damp-proof courses (dpc).

In structures below ground, groundwater must be prevented from reaching the interior of a building, commonly by waterproofing in the form of externally applied tanking membranes of mastic asphalt or bituminous sheet.

The thermal performance of a ground floor can be boosted by thermal insulation materials. These should be appropriate to each application and should have the required density or compressive strength, and relevant water absorption characteristics.
Ground floors can be retrospectively fitted with insulation, but this is usually only economically viable during a major refurbishment.

Insulating concrete ground floors above and below a structure require different approaches – described in Bites 2 and 3.

Picture 1

2.0 Insulating concrete ground floors below a structure

Insulation below the main floor structure should be rigid boards featuring a high moisture resistance and compressive strength.

Insulation must be prevented from becoming deformed when ground-supported slabs are cast directly onto it, potentially resulting in subsidence, unexpected floor stresses or reduced thermal performance. Compression or degradation of insulation from chemical reactions to ground contaminants must also be avoided. BRE guidance suggests:

- Using insulation with sufficient compressive strength to resist the concrete placing, the completed slab, the anticipated floor loading in use and any possible overloading.
- Using insulation with low water absorption and a high resistance to chemical attack.
- Providing a level support for the insulation by ensuring that all hardcore and fill materials are well compacted and covered with sand blinding.

Damp-proof membrane (dpm)

All in accordance with Approved Document C – Site Preparation and Resistance to Contaminants and Moisture.

The dpm may be placed above or below the concrete slab. If below, the dpm can be placed above or below the insulation. If above, the insulation must be resistant to contaminants from the ground or fill material. Landfill sites or ground containing high levels of sulphates, may require an additional membrane beneath the concrete. Placing the dpm above the insulation prevents concrete running into gaps if the insulation has been fitted poorly and ensures sharp objects in the blinding or fill material cannot puncture the dpm.

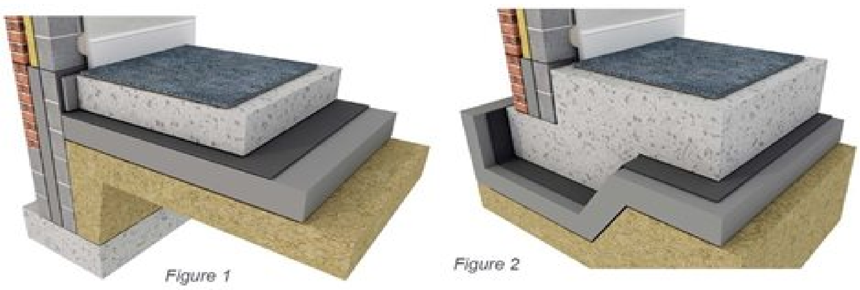
Thermal bridging

Breaks in the integrity and continuity of horizontal floor insulation at junctions between the floor and external walls or load-bearing internal walls will create a thermal bridge risking localised surface condensation, and mould growth. Vertical perimeter insulation to the floor at junctions of external and loadbearing walls can help mitigate this.
Further information can be found at Robust Details.

External wall cavity insulation should be extended below the dpc and base of the floor slab. Where appropriate, construct the outer wall below dpc level using lightweight concrete blockwork. A vertical strip of insulation around the floor slab perimeter, overlapping cavity insulation or linking with internal wall insulation, can be used where appropriate.

Internal load-bearing walls penetrating the floor structure should have a vertical strip of insulation placed against internal faces of the wall, or lightweight concrete blockwork used below floor level.

Risk of thermal bridging at external doors thresholds may be increased where a level threshold detail is necessary. Here, insulation can be returned along the edge of the floor slab.



Picture 2

3.0 Insulating concrete ground floors above a structure

Insulation above a concrete floor is generally associated with suspended pre-cast construction, such as concrete beam and block systems. Insulating above the structure is suitable where an existing concrete or timber suspended floor is being replaced or overlaid by a new floor structure.

Insulation can be installed above an in-situ concrete floor provided the dpm is placed above the structural slab, reducing the risk of damage to moisture sensitive floorings. The insulation is normally placed below a timber-based flooring system or a relatively thin sand cement screed. Insulation should be rigid and suitable for the loading requirements of the floor.

A timber-based flooring system may require a concrete levelling screed to provide a suitable level surface to receive the insulation and ensure a level floor finish.

The insulation board should have adequate compressive strength for the intended purpose. Where additional floor loading is anticipated – eg below kitchen and sanitary fittings, static equipment or door openings – timber support battens should be provided. Cement sand screed finishes should be a minimum 65mm thick. The screed should be thoroughly compacted throughout its thickness. A separating layer such as building paper or polyethylene sheet should be positioned above fibrous insulation to prevent it from absorbing moisture from the wet screed.

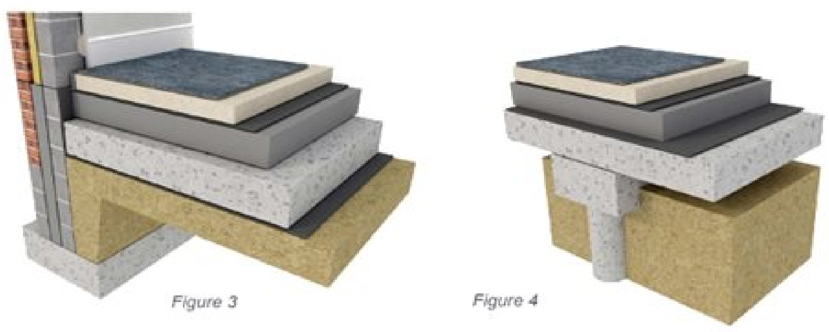
Underfloor heating pipes can be positioned above the insulation, and a screed finish, or a floating timber floor can be incorporated above the underfloor heating.
A 500 gauge separating layer is recommended between the insulation and the screed / floating floor finish

Some plastic insulation products may be damaged by solvents in some liquid dpm materials and adhesives. It is recommended to use solvent-free damp proof membrane products and adhesives to avoid any reaction with the insulation.

Moisture-sensitive floorings including timber-based flooring panels (particularly chipboard) can be seriously disrupted or damaged by water vapour arising from moisture within the floor construction. If there is no dpm above the concrete floor, a vapour control layer, such as polyethylene, should be placed between insulation and screed to protect moisture-sensitive finishes. The screed should be allowed to dry before any floor finish is laid.

Thermal bridging

Potential thermal bridges can occur at junctions of the floor and external walls or around service penetrations. Ensure continuity by linking with internal insulation or overlapping with cavity insulation. The use of lightweight concrete blocks for the inner leaf below the floor slab can reduce the risk of thermal bridging.



Picture 3

4.0 U-values and insulation product performance

The U-value or thermal transmittance of a building element or component is a measure of its ability to conduct heat from a warmer environment to a cooler environment. It is expressed as the quantity of heat (in watts) that will flow through one square metre of area divided by the difference in temperature (in degrees K) between the internal and external environment. The resulting unit is W/m²K.

For example, if a square metre of area allows one watt of heat to pass through it when the difference in temperature is 1°C, then the U-value of that element is equal to 1W/m²K.

The calculation of a U-value is often complicated by the presence of repeating thermal bridges, such as gaps and voids.

The rate of heat loss through a ground floor varies with its size and shape. If the floor is over 400 m2, it is possible to achieve a target U-value of 0.35 W/m2 K without the use of any additional thermal insulation. For most housing and other small buildings, thermal insulation will be needed to meet this target value. Its thickness will depend upon its thermal conductivity value and the floor's shape factor. This is a simple ratio of heated perimeter length divided by heated perimeter area, or P/A. Most of the heat from a floor is lost around the perimeter. Large floors with a low P/A ratio may require only perimeter insulation to achieve the required U-value.

Wall thickness and ground conditions can affect U-value calculation. Clay, sand/silt and rock each have different thermal resistance. An unheated space adjoining a roof, wall or floor construction will act as a buffer, reducing heat loss and thereby reducing U-values. Most wall and roof constructions, as well as most types of floor decks, may be assessed using the U-value calculation method given in BS EN ISO 6946 and CIBSE Guide A3. These describe the combined method for repeating thermal bridges and give correction procedures for the effects of metal fixings, air gaps, rainwater percolation and unconditioned buffer spaces.

Energy calculation tools such as the Standard Assessment Procedure and the Simplified Building Energy Model (together with its user interface iSBEM), which support the national building regulations for energy conservation as well as the production of Energy Performance Certificates, ensure that U-values and thermal mass values can be reliably calculated for a range of construction types.

		U-value 0.25 W/m² K		
		thickness required (mm)		
Insulation material	λ(W/mK)	P/A=0.40	P/A=0.60	P/A=0.80
Polyurethane	0.023	50	60	65
XPS	0.031	66	78	86
EPS	0.038	80	95	105

Picture 4

5.0 Floors and applied loadings, and radon

Floors must be designed as a whole element, accounting for all functional requirements.
Intermittently heated buildings are usually designed with 'fast thermal response' fabric (low thermal mass) with thermal insulation inside the structure. Heating systems using the structure as a heat store (high thermal mass) require extensive thermal insulation of the structure.

Foundation and groundbearing floor design is influenced by intended building location and loadbearing capacity of soil should be established before design work commences.
Floors must support loads placed on them during a building's life. Some have predictable loadings, unlikely to increase with time. However, others, especially industrial buildings, change of occupancy or processes may require increased floor strength compared to the original purpose.

All materials compress when subjected to loads. When choosing insulation, static point loads (eg. shelving in warehouses) or dynamic loads (eg. forklifts) must be taken into account.

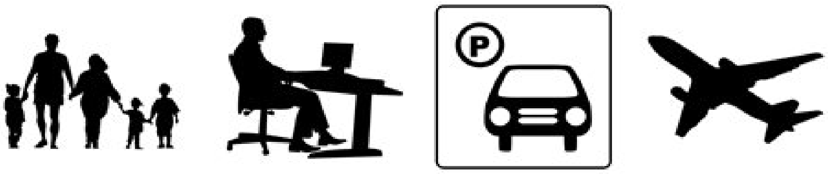
Extruded polystyrene (XPS) offers different grades of compression strength to suit building designs and uses. Compressive strength (reduction in thickness caused by a point load) and compressive creep (long-term load) are standard mechanical properties of XPS declared as part of the CE Marking under EN13164.

Radon

Radon, a naturally occurring, colourless, odourless, radioactive gas, usually disperses harmlessly into outdoor air, but some collects in spaces under or within buildings. In some UK areas, special precautions are necessary to reduce entry of radon gas, including protection barriers; a membrane of 300 micrometre (1200 gauge) polyethylene barrier, a cavity tray in the dpc to cavity walls, and joint sealing around service penetrations. Details of locations at risk of radon may be found at www.defra.gov.uk.

Health & Safety

As is true of the manufacture, production, distribution and application of all construction products, due care and attention should be paid to prevent harm or injury. Suitable PPE should always be worn around manufacturing and construction sites. It is the user's responsibility to determine the conditions necessary for the safe use of any product.
XPS insulation is not a hazardous substance or mixture. Nevertheless, care should be taken prevent injury whilst handling and installing. Mechanical cutting, grinding or sawing can produce dusts, which may cause respiratory irritation or discomfort. To limit this, adequate ventilation should be ensured. Eye protection should not be necessary when installing, but appropriate gloves are recommended to protect from mechanical injury. During shipment, storage, installation and use, XPS should not be exposed to flame or other ignition sources.



Picture 5