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Cavity insulation

The thermal insulation of a masonry cavity wall can be greatly improved at modest cost by the introduction of insulating materials into the cavity. This can reduce the heating costs of a dwelling by up to 25 per cent (although in some cases the benefits will be taken, at least in part, in improved comfort) and if the cost of the insulation is considered in terms of an investment, it will often give a good return. In new constructions, the lower heating demand can allow economies in the cost of the heating installation. As well as a cut in heat loss, the inner face of the inner leaf will be warmer than if no insulation were present and there will be a consequent reduction in the risk of condensation.

But against these advantages must be weighed an increased risk of rain penetration through the wall in some conditions of exposure. This digest discusses this form of insulation and is based on several years experience of its use and on simulated rain penetration tests.

A continous wall cavity, with properly designed and installed damp-proof courses and cavity trays, offers very good protection against penetration of rain. In driving rain conditions, water may not only be absorbed by the brick though capillary action; it can also leak through the outer leaf of facing brickwork and run down the cavity. The actual extent of the penetration of the outer leaf depends on its absorption capacity, on the quality of the jointing, and on the severity and duration of the driving rain. In a clear cavity, with correctly installed wall ties and detailing, the water flows freely and harmlessly down the inner face of the outer leaf to the base of the cavity unless deflected outwards through the leaf, for example by intervening cavity trays. Often walls are not perfectly constructed and rain penetration occurs even in unfilled cavities, caused, for example, by debris within the cavity or ties sloping downwards from the outer leaf. However, when cavity fill is introduced, the free flow of the water may be impeded and it is more likely to find any faults at cavity trays, vertical damp-proof courses or wall ties. Water may also cross to the inner leaf through gaps, fissures or voids in the fill. The extent and severity of this is discussed later.

The introduction of thermal insulation around electric cables carries a risk of the cables overheating, depending on the type of insulation and the loads on the cables. The insulation contractor should ascertainwhether the space to be filled contains any cable runs and should advise whether the cables should be replaced by ones with larger conductor sizes; guidance is given in the IEE Wiring Regulations.

Building Regulations

In new buildings

Building Regulations (England and Wales, Part F) now require a maximum U-value of 0.6W/m^2 °C for the external walls of new housing. Cavity insulation provides a relatively inexpensive and straightforward means of meeting this requirement with little alteration to other features of the building process.

A number of Building Regulations relating to weather resistance of walls are applicable to new buildings and, in certain forms of construction, Regulations relating to fire may also impose limitations on the methods of cavity insulation.

In existing buildings

For the filling of cavities in most types of existing buildings in England and Wales, there is a 'Type Relaxation Direction' which, subject to certain conditions, directs that the Regulations relating to bridging cavities are dispensed with. Work covered by a British Board of Agrément or British Standards Certification scheme (the BS scheme applies at present only to urea formaldehyde foam) will satisfy most of the criteria. These schemes require operatives to undergo approved training. Where the Type Relaxation applies, the local authority requires notification at least seven days before the date of installation; where it does not apply (eg flats, maisonettes, buildings over three storeys (12m) or with unconventional walling) a longer application procedure is involved. The installer will usually deal with the application on behalf of the building owner.

The filling of cavities in existing buildings is not restricted by regulation in Scotland.

Insulating materials and installation

Materials fall into two types; those inserted during the construction of a wall in the form of slabs or boards, and those inserted into a completed wall by blowing or injection. These are in the form of loose fibres, beads, granules or foam.

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New Walls

When cavity insulation is considered during design, the number of methods available is greater than for existing buildings because insulation can be introduced during construction. Furthermore, it can be ensured that detailing and materials are compatible with the insulation material having regard to the exposure of the building. If installation is to be delayed until after the walls are completed, the material can be injected into the cavity through the inner leaf; making good then forms part of the plastering work (it is usual in existing buildings to inject only through the outer leaf).

All types of cavity insulation inhibit ventilation of the cavity and the drying of masonry materials may, therefore, be slowed down. Normal practice of decorating with a permeable water-based emulsion should be followed as this will allow drying to continue. The application of an impermeable covering should be delayed until the inner leaf has dried sufficiently; this will usually be one full heating season.

Glass and rock fibre slabs Although the slabs themselves are very effective barriers to water, the joints between them may be vulverable if the slabs are not installed with care. Wide gaps between adjacent slabs must be avoided and any mortar droppings prevented or removed: good site supervision is therefore important. Often the inner leaf is built up first to a height of at least one slab, the slabs placed against this, and the outer leaf then built. With this order of construction, mortar can be extruded from the outer leaf into the joints between the insulating slabs. Subsequently, in driving rain, these extrusions can divert water into the joints and hence lead to penetration across the cavity. A better practice is to build the outer leaf ahead of the inner leaf and carefully to clean off the cavity side to that a smooth surface is presented to the exterior side of the fill.

In England, it is usual to build the inner leaf first, especially above the first lift of brickwork where only an external scaffold is used. In these circumstances, a trough, one brick high, can be built before placing the insulation batts against the inner leaf. The mortar extrusion adjacent to the critical joint between the insulation slabs can then be removed before placing the slab. The trough should not be deeper than one brick course because mortar might drop on to the horizontal joints between the slabs, either during construction or as it is scraped off the cavity faces as the slabs are pushed in. Also, slabs become scuffed and distorted if they are pushed into deeper troughs.

Partial fill boards The insulating boards are usually fixed to the inner leaf, leaving a clear cavity of at least 25 mm, although 50 mm is preferred. Special fixings, generally fitted to the ties, are available for the purpose. Good site supervison is important to make sure that the boards are restrained by the fixings and do not lean across the cavity. It is recommended that the cavities are designed to leave 50 mm clear with the boards in place, since it is difficult to keep a narrower space clear of mortar droppings. Agrément Certificates for this product specify different exposure restrictions, depending on the width of the remaining cavity. Boards of thickness 25 mm are often used. Materials within the normal range of conductivities will not reduce the U-valve of dense masonry sufficiently to meet the Building Regulations, so thicker boards or a lightweight inner leaf will be required. If thicker boards are used, longer ties may be needed. Polyurethane boards can have conductivites which allow them to meet Regulations at 25 mm thickness.

Completed walls

Urea-formaldehyde (UF) foam By far the most commonly used form of cavity fill in the UK, this accounts for well over one million installations to date. The material is a low-density cellular plastics foam which is produced by foaming together in a 'gun' a mixture of water-based resin solution, a hardener-surfactant solution, and compressed air. The foam, which has a consitency rather like shaving cream, is injected into the cavity where it subsequently hardens and dries. As it dries it will normally shrink and this will lead to fissuring. Occasionally the fissures are able to provide a bridge which will allow water to cross from the outer leaf to the inner leaf.

On the basis of the considerable amount of information and experience which has been accumulated for UF foam, two British Standards have been published which deal specifically with this fill. BS 5617 covers materials' standards for normal quality control of the foam and constituents. This allows a linear shrinkage of up to 10 per cent for samples taken on site. BS 5618 is a Code of Practice for the technique of installation and gives rules for the climatic exposure conditions appropriate to this type of fill when used in masonry cavity walls.

When UF foam is injected, and for some time after, it gives off formaldehyde vapour. For a normal cavity wall of two leaves of masonry, plastered on the inner leaf, the risk of formaldehyde entering the building is low provided that the walls are of sound construction. Should it occur, it is likely to be transitory, and to give rise only to low concentrations; the effects can be overcome by temporarily increasing the ventilation of the building as advised in BS 5618. If however there are defects or unsealed openings in the inner leaf of the cavity walls, concentrations high enough to cause discomfort through irritation to the eyes and respiratory tract, particularly of sensitive people, can occur. A survey of the inner leaf to assess its effectiveness as a barrier should be carried out before the cavity is filled, as required by British Standard 5618. This is particularly important where the inner leaf is of non-loadbearing masonry, eg thin concrete panels, or where the cavity is wider than 100 mm. If the inner leaf is to be of exposed brickwork or is to be dry-lined, the cavity should be filled only during construction so that the formaldehyde vapour is dispersed before occupation.

In other forms of construction (which fall outside the recommendations of BS 5618) where there is no masonry inner leaf, the risk of formaldehyde ingress is high. Such buildings may have plasterboard or other thin wall linings attached to a sub-frame. The vapour permeability of these lightweight linings is much greater than that of a plasterboard masonry wall. Measures to prevent the vapour diffusing through the lining are likely to be costly and difficult to perform. In these circumstances the use of UF foam is not recommended.

Part S of the Building Regulations (1976), operative since 31 March 1983, allows the use of urea-formaldehyde foam only for cavity walls in which the inner leaf is constructed of bricks or blocks. There is also a requirement that for such walls all reasonable precautions should be taken to prevent subsequent permeation of formaldehyde into occupied spaces; this is deemed to be satisfied if the foam is installed in accordance with BS 5617 and 5618.

Rock fibre Fibres coated with a water repellent are blown as tufts into the cavity where they form a water-repellent mat. Although the second most widely used fill in this country, the number of installations is lower than for urea-formaldehyde foam. Although the price of installation depends on location because of transport costs and other factors, the raw materials cost is higher and so it will generally be more expensive than urea-formaldehyde.

Installation of blown mineral fibres (both rock and glass) are covered by British Standard 6232:1982. The Standard was developed at a stage when most systems tended to use large cored filling holes at wide spacings. More recently there has been a move towards using smaller holes at closer spacing, but certain aspects of the Standard are still applicable.

Polyurethane granules These are irregularly shaped granules usually between 5 mm and 20 mm across, made by chopping waste rigid polyurethane foam. At present the fill is most widely used in the north of England. Polyurethane is combustible and gives off toxic gases when burning. However, in conventional masonry/cavity/masonry walls, the material is normally sufficiently protected to prevent any hazard. The material should be kept away from hot surfaces such as flues built into or crossing the cavity.

Expanded polystyrene (eps) loose fills Expanded polystyrene beads are white spheres with a diameter between 2 mm and 8 mm. They are extremely free running and so very few filling holes are necessary. The wall is usually drilled high up, with additional holes under obstructions such as windows. The free running nature of this insulant can lead to an unnoticed escape of material where there are holes in the inner leaf, for example round joist ends or service pipes and ducts, so that particular attention must be paid to these points. Polystyrene granules are made by shredding waste eps bead board; they are about the same size as beads but since they are irregularly shaped they do not have the same properties and there is less risk of escape. Bonded eps beads are spherical beads which are thinly coated with adhesive as the fill enters the wall. The adhesive sets and so prevents subsequent escape. Polystyrene is flammable, but as for polyurethane, this should not be a hazard in a conventional masonry/cavity/masonry wall. However, the fill should be kept away from hot flues. If expanded polystyrene comes into contact with pvc-coated electrical cable, plasticiser can migrate from the pvc leading to embrittlement of the cable insluation. Provided the cable is not disturbed, the electrical insulation will remain intact. Even so, the problem is best avoided by not using polystyrene in cavities where contact with such cables is likely to arise.

Glass Fibre This material has much in common with rock fibre and it is installed by a similar method. However, it is less dense when installed and material costs are therefore lower. But the materials are not identical and they may behave differently. The comments on BS 6232 in relation to rock fibre apply equally to glass fibre installations.

Polyurethane foamed in-situ Two liquid components are mixed and injected into the cavity where they spontaneously foam and rise to fill the space; the foam adheres strongly to masonry and does not shrink. It has, therefore, been used to stabilise cavity walls where the wall ties have corroded but at the density required for this application the material cost is very high. A lower density foam has come into use recently specifically as a cavity insulant, but is at present the only material discussed in the digest not to have an Agrément Certificate.

Rain penetration - experience and simulated tests

Surveys on the extent and circumstances of rain penetration were carried out by the British Board of Agrément in 1970 and by BRE in 1973. Both surveys gave statistically meaningful results only for UF foam because of its predominant use over the other materials. Results were largely similar and showed that buildings with low exposure to driving rain had a low risk of rain penetration. The BRE survey of 30 000 UF-filled low-rise dwellings showed also that buildings filled some time after completion produced fewer reports of penetration (0.2 per cent) than those filled during or immediately after construction (3.3 per cent). The reasons for this significant difference are not altogether clear, but the ability of interior decorations to conceal dampness is one factor.

Simulated rain tests have been caried out by BRE on over 30 houses. In most cases the houses were tested before and after the installation of cavity insulation. Inspection of the empty cavities before filling showed a high number of faults such as sloping ties and debris but this was typical of other sites where cavities have been inspected. When tested, only in some cases did the faults cause water to cross the cavity; in a few of these significant dampness showed internally. The filled cavities however, showed a wide range of performance attributable to two principal factors; the brickwork of the outer leaf and the properties of the insulation. Where the outer leaf was of dense clay bricks, which are unable to absorb and retain water easily, leakage into the cavity (and in some cases across it) began soon after application of water to the outside surface of the wall. As the outer leaves of these walls allowed most of the applied water to leak into the cavity, the spraying presented a severe test to the cavity insulation and to any building fault within the cavity.

Blown-in rock fibre and polystyrene beads allowed least water penetration. In-situ polyurethane of intermediate density (about 30kg/m^3) also showed good resistance and prevented water penetration at some wall ties which, before filling, had conducted water across the cavity. Very careful installation is required for this fill to achieve its full potential; material costs are high but cheaper, less dense polyurethane has proved less successful in tests.

Although attempts have been made in tests to simulate driving rain storms, using the results to predict performance in practice is complicated. One approach is to relate the performance of filled and unfilled walls and compare the risk of filling to the possibility of faults in unfilled cavities causing penetration. Tests indicate that the better materials may introduce faults equivalent to only small amounts of debris, whereas fissures in UF foam are usually equivalent to larger obstructions in an empty cavity. Whether such faults create problems depends on a number of factors but experience indicates that many poorly constructed cavity walls perform satisfactorily.

Clearly, one of the important factors governing the risk is exposure to driving rain. A widely used scheme in BS 5618, and in British Board of Agrément Certificates for some types of insulation, assesses the exposure of an individual building. It takes into account the local annual driving rain idex, the shelter provided by surrounding buildings and the local topography. The scheme sets lower limits of exposure for low-porosity stonework, concrete blocks and calcium silicate bricks than for clay brickwork, but tests and experience suggest that less absorbent clay bricks should be included with low porosity materials and therefore treated more cautiously.

Walls which are tile hung or clad, or have rendering in good condition, give adequate protection from driving rain.

Rain penetration - remedial measures

Rain penetration can usually be distinguished from other causes of dampness because it will follow spells of particularly heaving driving rain. Any remedial work must be based on sound diagnosis; it may be difficult to establish the part played by cavity insulation especially if there are building defects and if the insulation has been introduced before the structure has been tested by storms.

Remedial measures that have been used include insertion of more insulation materials, clearing obstructions from the cavity, and the use of colourless water repellents such as silicones. In rare cases it has been necessary to clad or render the wall, or to remove the material from the cavity.

Durability of material and walls

All the materials currently used for cavity insulation should be expected to last the lifetime of the building without significant deterioration; urea formaldehyde and polyurethane foams will do so if they are processed and installed correctly whilst granular materials are inherently durable.

Settlement of particle fills should be negligible since the vibrations to which buildings are normally subjected will not be sufficient to distrub the fill. Although blown fibre fills may appear from their nature to be susceptible to slump, observations of rock fibre have indicated that the fill still extends almost to the top of the cavity some years after installation.

With cavity insulation, the outer leaf will be colder than with an unfilled cavity. Also, the moisture content of the outer leaf can be expected to be somewhat higher, due to the lower temperature and, possibly, to restricted drying into the cavity. It has been suggested that this will increase the risk of frost damage to cavity filled walls. Tests have shown that in cold weather the temperature of the external face is about 1°C below that of an unfilled wall and that the moisture content is indeed somewhat higher. Experience so far has shown that these differences are not a significant cause of frost damage, but where the materials in existing buildings already show signs of frost damage, or cracked rendering, which may permit higher than normal moisture contents in the outer leaf, insulation of the wall can be expected to increase the rate of deterioration.

If the external brickwork is painted, care should be taken to check the integrity of the paint film and to ensure a good standard of maintenance. Defects may allow water to penetrate into the brickwork and subsequent drying will be retarded by the paint on the one side and the fill on the other. Painting a filled wall should be carried out only when the wall has had ample time to dry.

Timber framed construction

This construction usually has a 50 mm cavity separating the timber frame from a brick external leaf. This cavity should remain open to provide adequate ventilation for the timber frame and therefore should not be filled with insulating material.

References and further reading

The British Board of Agrement PO Box 195, Bucknalls Lane, Garston, Watford, Herts. WD2 8NG.

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Part 2: Code of practice for installation of blown man-made mineral fibre in cavity walls with masonry and/or concrete leaves.

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