Building Research Establishment Report

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Sealing cracks in solid floors:
a BRE guide to radon remedial measures in existing dwellings

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INTRODUCTION

This report is one of a series giving practical advice on methods of reducing radon levels in existing dwellings. It is intended for the guidance of householders and builders who seek to reduce radon levels in dwellings by sealing cracks and other discontinuities in solid ground floors. The remedial measures described are mainly for concrete floors laid directly on the ground but some of the principles could be used with suspended concrete floors and, to a lesser extent, with floors consisting of large stone slabs. The sealing measures described are not suitable for use on suspended timber floors; it is intended to produce another BRE guide on how to deal with these.

Before reading this guide you should read *The householders' guide to radon*[1], which is obtainable from your local Environmental Health Officer or direct from the Department of the Environment. It recommends that if the amount of radon in a dwelling is above the Action Level of 200 Bq/m^3, action should be taken to reduce it. The advice given in the present guide is made on the assumption that measurements of radon levels in the building show that it is over this level.

Entry of radon into a building

Radon is drawn into a building from the ground because the atmospheric pressure inside a building is usually slightly lower than that in the underlying soil. This small pressure difference is caused by the stack (or chimney) effect of heat in the building and the effects of wind. To prevent radon entering a building this pressure difference can be reversed by constructing a sump[2].

Under normal conditions air containing radon gas from the ground enters a building through cracks, gaps, holes and joints in the floor (Figure 1). It does not enter in any appreciable amount by directly penetrating or diffusing through concrete or other solid materials.

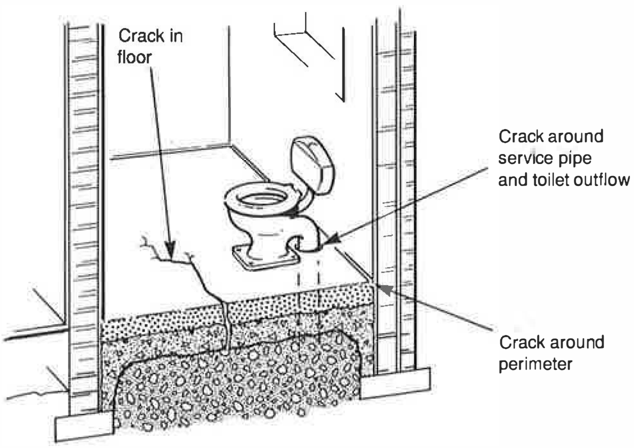

Figure 1 Cracks in ground floors: radon entry points

Use of sealing to prevent radon entry

A sensible approach to the problem suggests that if all the cracks, holes, etc, could be blocked by sealing them, then the supply of radon into the building from the soil would be cut off and radon levels would be reduced.

However, in practice it has been found that the reduction in radon levels achieved by sealing is not always as large as hoped. Sealing solid floors has produced reductions of a half to two-thirds on average. The reasons for this are not entirely clear but probably result from the fact that it is difficult to ensure that all the cracks are found and treated and that the sealing treatment of any crack is fully effective.

In particular, cracks and joints behind kitchen units, built-in cupboards and boxed pipework can be easily overlooked and can provide major flow paths for radon entry. Under staircases can be difficult to treat as well. To gain adequate access, fixed cupboards standing on the floor will usually have to be removed. Trying to seal cracks by removing cupboard plinths and working through the low openings provided will rarely be successful. Boxed pipework should be opened at ground level so that a proper assessment can be made of the sealing requirements.

Some of the poor results achieved with sealing may be caused by an incorrect type of sealing compound being used and poor diagnosis of the type of crack to be sealed.

In spite of the disappointing results reported, sealing remains an attractive remedial treatment for radon levels up to about 400 to 500 Bq/m^3. Sealing is cheap, does not cause too much disruption and is passive, ie it costs nothing to run. Tracing and sealing all the cracks can be very time consuming but it is attractive to householders carrying out their own remedial measures as the material costs are low and it can be relatively expensive to employ a builder.

Before any treatment is applied it is necessary to identify the type of solid floor to be dealt with, its condition, the size and position of cracks and holes, and whether these discontinuities are static or whether they will move in the future (because of thermal movement, settlement, etc). All these factors may be required to be known so that the most appropriate sealant can be selected. In some buildings it may be economic to use more than one type of sealant.

TYPES OF SOLID FLOOR

(a) Directly laid on the ground, between walls

This is the most common construction. In most post-war houses the floor is a concrete slab of minimum thickness 100 mm (4 inches). The concrete will have been poured directly over the hardcore in contact with the ground, with the masonry walls being used as permanent shuttering to contain the concrete.

The result is a simple butt joint between the concrete and the wall. Often a screed will be found overlying the slab. This will commonly be 35–60 mm (1½–2½ inches) thick. A damp-proof membrane (dpm) will usually have been placed either under the concrete, in which case it will be polyethylene sheet, or on top of the concrete slab beneath the screed, when it is most often found to be black, the main constituents being pitch or bitumen.

Wood-framed partition walls may have been fitted after the laying of the concrete slab and either before or after laying of any screed. In older houses a concrete floor might have replaced a suspended timber floor with vertical members of existing wood-framed walls cast in the floor. These floor/wall junctions can be difficult to seal.

(b) Raft construction
This is not a common form of construction for houses. It comprises a reinforced concrete slab which is thickened in a downward direction at the perimeter and at other positions where loadbearing walls are built off it. This type of construction can sometimes be recognised as a concrete plinth, often visible around the outside perimeter of the property up to damp-proof course (dpc) level. Inside the house the floor may look similar to type (a) as a screed is commonly laid over the slab between the walls.

(c) Suspended concrete construction
This type of construction has been widely used only in the last ten years. The most common form consists of precast concrete beams which are supported on and built into the loadbearing walls. Concrete blocks are slotted in between the beams. There should be an air space beneath the beams and blocks of not less than 125 mm (5 inches). Commonly a screed is laid over the beams and blocks. Alternatively, it may be covered with chipboard flooring usually supported on a layer of foamed plastics insulation board. Chipboard floors are not discussed in this publication.

TYPES AND LIKELY POSITIONS OF CRACKS
All products based on Portland cement shrink as they dry out. Concrete bases and screeds are no exception. As these elements dry out, almost certainly a gap develops between the wall and the floor where they meet. With floors directly laid on the ground (type (a)) this discontinuity will continue for the whole depth of the concrete. This provides a path for radon gas from the ground into the house. This shrinkage gap is most often hidden by a skirting board.

Owing to incomplete compaction of hardcore, settlement of such concrete floors (type (a)) is common in the first few years after construction. Settlement will enhance the perimeter crack between floor and wall, and as the slab drops a large gap may appear between the floor surface and the skirting board because the latter is fixed to the wall (Figure 2).

Uneven settlement, sometimes aided by shrinkage, can produce random cracks running across slabs to the full thickness of the base. Such floors can be difficult to seal.

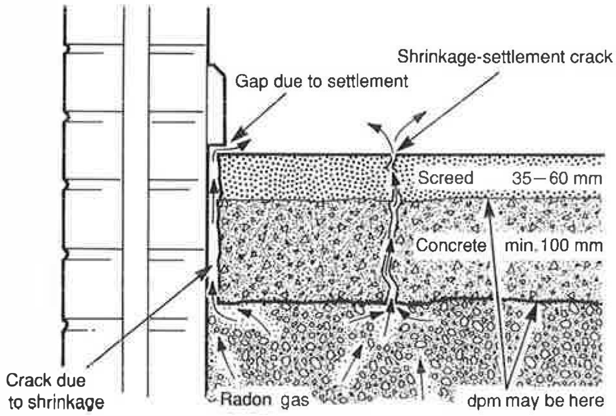

Figure 2 Concrete base and screed floor: radon entry points

In some older properties the thickness and the quality of the base may be significantly below modern standards. This can lead to a multitude of cracks appearing in the floor. It is most unlikely that a floor of this type can be successfully sealed, and replacement with a new base slab incorporating radon protective measures should be considered. The new slab should be sealed at the edges and a sump and extract pipe could be included. This would be connected to a fan only if radon levels remained high.

Another common position for cracks is at joints in the base where adjacent bays of concrete have been laid on different days. They are often formed at thresholds to rooms. These joints are a weakness and often they open from the effects of shrinkage and settlement to form a significant gap.

With raft construction (type (b)) no shrinkage gap should develop through the slab although one may occur between the screed and the wall. This gap is of no consequence with this construction as it does not provide an air path to the underside of the slab. However, there may be joints where extensions have been built. Settlement does not normally cause cracking in type (b) floors.

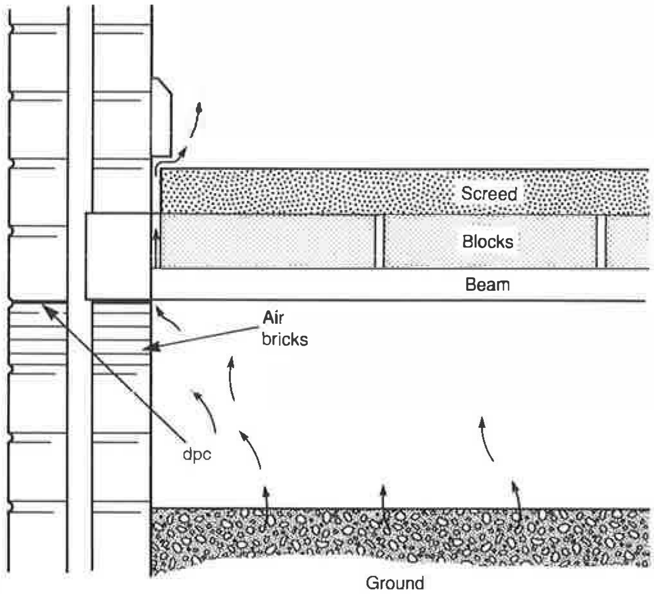

Figure 3 Suspended concrete construction beam-and-block floor: radon entry points

With suspended concrete construction (type (c)) the shrinkage gap between screed and wall connects the underfloor space with the room above (Figure 3). Cracking due to settlement is rare with this type of floor and only occurs if the walls on which the beams rest move unevenly.

SERVICE ENTRIES

These include the entry of gas, water and electricity and the exit of waste and soil pipes (Figures 4 and 5). Most of these would have been in position when the floor slab was cast so that only a small shrinkage crack should surround them. However, some entries may have been made by breaking out holes through the base or leaving large holes to allow later installation. These may have been poorly refilled.

With beam-and-block floors, whole or half blocks may have been left out to provide service entries.

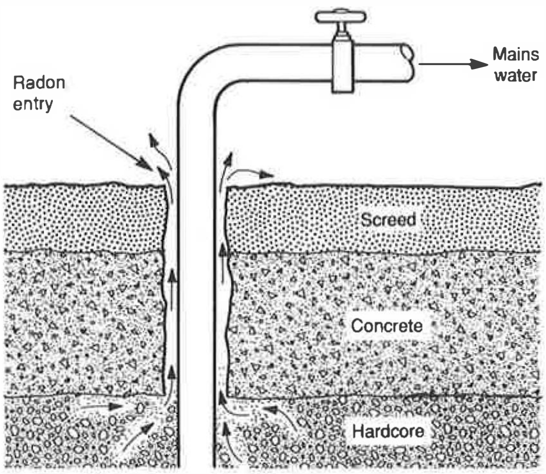

Figure 4 Mains water pipe: radon entry point

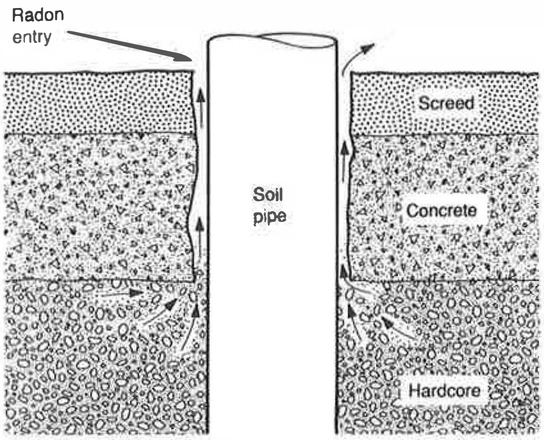

Figure 5 Soil pipe: radon entry point

SEALANTS

Clearly the function of any sealant is to block the discontinuity, so preventing the ingress of radon into the building. It must be able to accommodate any movement which occurs as a result of thermal expansion and contraction or one-way movement from shrinkage and settlement. Ideally it should stick to both sides of any joint and maintain that adhesion.

Table 1 summarises the main sealants recommended to fill the types of cracks found in different floors.

Table 1 Sealants recommended for use with different types of crack found in solid floors

Type of solid floor	Crack type	Main sealant type
(a) Directly laid on the ground between walls	Shrinkage gap between wall and floor	Acrylic sealant or silicone sealant
	Cracks due to uneven settlement	Polymer emulsions mixed with neat cement
	Construction joints	Acrylic sealant or silicone sealant
	Service entries	Expanding polyurethane or polymer-modified cement mortars, or acrylic for small cracks
(b) Raft construction	Shrinkage gap between screed and wall	No sealant
	Joint between main house and extension	Acrylic sealant or silicone sealant; expanding polyurethane for large cracks
	Service entries	Expanding polyurethane or polymer-modified cement mortars, or acrylic for small cracks
(c) Suspended concrete construction	Shrinkage gap between screed and wall	Acrylic sealant or silicone sealant
	Random cracks	Polymer-modified cement mortar for large cracks and acrylic or silicone sealant for small cracks
	Service entries	Expanding polyurethane or polymer-modified cement mortar or acrylic for small cracks

Many types of sealants are available commercially and most of them have suitable performance characteristics for sealing cracks in floors. Many of these are not readily available at DIY outlets or small building suppliers and are mainly sold to specialist trades. Some are two-part materials and are therefore less easy to handle with limited pot lives.

The following fillers and sealants are recommended because they are easily obtainable, relatively easy to use, pose few health hazards if used correctly and are economic. Because a type of sealant material is not mentioned here, it does not mean that it is unsuitable.

Acrylic (emulsion) sealants
These are readily available, have low health hazard, are easily paintable, are suitable for indoor use and will accommodate movements up to 10%. They are supplied in disposable tubes which can be fitted into a dispensing 'gun' and have a nozzle at one end through which the sealant is dispensed as a long bead. They cure by drying, like emulsion paint. The rate of curing is obviously dependent on temperature and humidity, but cure is normally complete within a day or two.

Silicone sealants (general purpose and 'low modulus' types)
These are readily available and will accommodate movements up to 20%, but they are more expensive than the acrylics, and are not readily paintable. They are commonly used to seal around sanitary ware, eg the joint between a bath and wall tiling. They are supplied in similar disposable tubes as acrylic sealants, but smaller quantities are available in 'tooth paste' tubes and other pressurised containers.

Expanding polyurethane sealants
These are dispensed from a pressurised aerosol can by a flexible plastics tube some 10 mm in diameter. They cure on exposure to the atmosphere but before doing so expand many times as they come out of the nozzle and continue to expand for some while before curing. They have only a limited use for filling cracks but can be used for filling larger voids and cavities, particularly around awkward places like service entries.

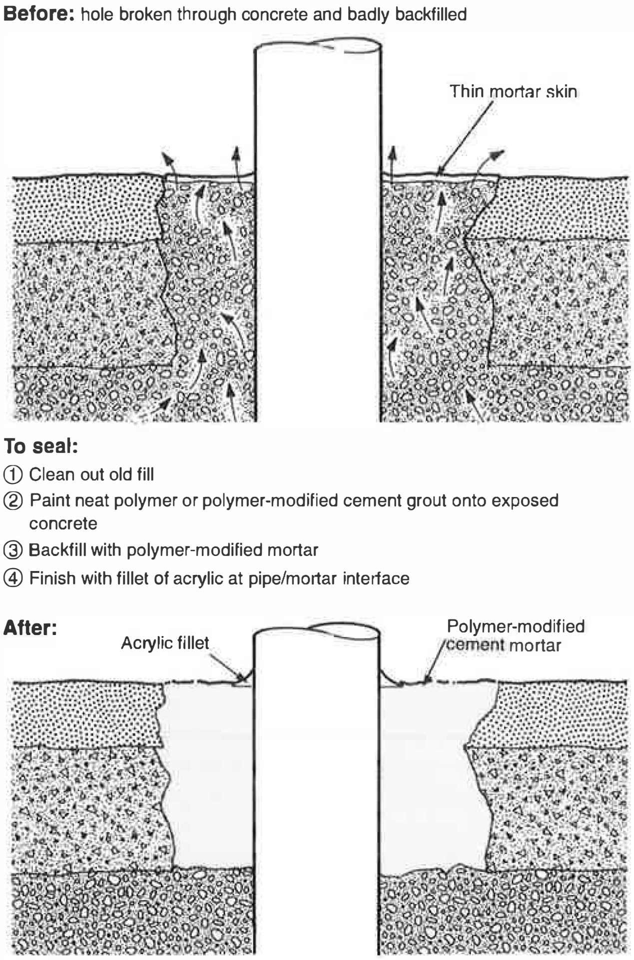

Figure 6 Sealing large holes around a service entry with polymer-modified cement mortar

Polymer-modified cement mortars (not strictly a sealant)
These are mixtures of cement and sand commonly in the ratio of 1:4 to 1:6 which instead of being mixed with water are gauged with a polymer emulsion. The latter are milky white liquids. Polyvinyl acetate (PVA), styrene butadiene (SBR) and acrylic polymer emulsions are suitable. The polymer emulsion modifies the sand/cement mortar to enhance the adhesion between the existing concrete and new mortar and to make the latter more elastic so that it does not crack so easily should further movement occur.

Polymer-modified mortars are most useful for filling large holes around service entries (Figure 6). Because they are robust and have good abrasion resistance they are very useful for filling large cracks and joints in areas which are to be walked on.

FILLING
The most common crack to be filled will be found around the perimeter of each room. This is best sealed with acrylic sealant (or silicone). For the most effective seal to be made it will be necessary to remove the skirting boards to expose the crack. Unless carried out with great care this may cause some minor damage to the plaster. All dust and loose material in the vicinity of the crack should be removed, preferably with a vacuum cleaner. The sealant manufacturer's instructions should be followed. The sealant should be applied as a bead from the dispenser nozzle and forced into the crack. It should then be pushed and tooled further into the crack with a wet spatula or similar tool. Finally a fillet of the sealant should be applied over the crack (Figure 7). When the sealant has set the skirting can be refixed.

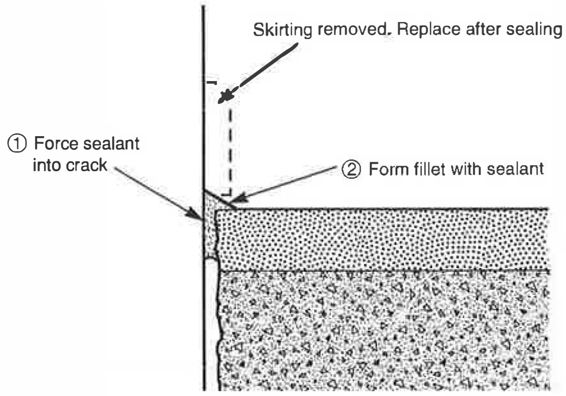

Figure 7 Application of sealant with skirting removed

If it is decided not to remove skirtings because of likely damage to decoration, then a less effective seal will be obtained. In these cases the sealant should be squeezed into the gap between the bottom of the skirting and the floor. Once again the joint should be finished with a fillet of sealant material although in this case it will be exposed to view (Figure 8). Any gap between the top of the skirting and the plaster must also be sealed.

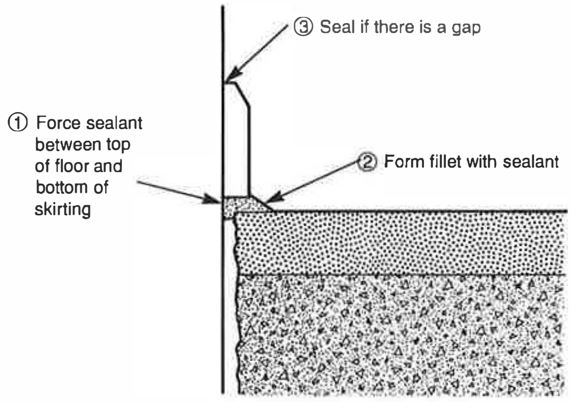

Figure 8 Application of sealant with skirting left in position

Plasterboard dry-lined walls can be particularly difficult to seal as the gap between concrete and wall can be hidden by the plasterboard. In addition there is usually a gap behind the board which can carry radon up to the intermediate floor level. With dry-lined walls good sealing can only be achieved with the skirtings removed.

Cracks, joints and other discontinuities are so varied it is impossible to give precise advice on filling and sealing. Very small cracks can often be filled by painting over with polyurethane or epoxy paints but bitumen and tar-based products should not be used. Good sealing of small cracks can also be achieved with polymer emulsions mixed with neat cement to form a fluid grout. This mixture can be flowed across the surface and forced down the cracks with a rubber squeegee.

Small cracks around service entries and soil pipes can be sealed with an acrylic sealant and finished with a fillet.

While sealing may prevent the entry of radon through a particular crack it may divert it to another entry point, for example into the gap behind plasterboard dry-lined walls and, in older houses, into lath and plaster walls or rubble-filled walls. Radon can then enter higher up the wall or at an intermediate floor.

After all the likely places where radon may be gaining entry have been sealed, a 3-month test of the radon levels in the building should be carried out using detectors supplied by the National Radiological Protection Board or any NRPB-validated laboratory. If the indoor radon level is still above the Action Level, a further survey should be undertaken to ascertain if any points of entry have been missed and need sealing. Further advice should be sought and it may be necessary to consider the installation of more comprehensive remedial measures such as a sump or creating a positive internal pressure.

REFERENCES

1 **Department of the Environment.** *The householders' guide to radon.* September 1992 (third edition). Obtainable from DOE, Room A518, Romney House, 43 Marsham Street, London, SW1P 4QU.

2 **Building Research Establishment.** *Radon sumps: a BRE guide to radon remedial measures in existing dwellings.* BRE Report. Garston, BRE, 1992.

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POTENTIAL SUPPLIERS OF SEALANTS, EXPANDING FOAMS AND POLYMER EMULSIONS

The companies listed must not be regarded or referred to as recommended suppliers. The Building Research Establishment cannot accept any responsibility for matters arising from the use of this list.

This list is not comprehensive; many other similar products are suitable. Any company not listed who claims to sell similar suitable products may contact the BRE radon team (P W Pye, BRE Advisory Service) and ask to be put on the list when it is revised.

Supplier	Acrylic sealant	Silicone sealant	Expanding polyurethane sealant	Polymer emulsions for cement mortars
Evode Ltd, Common Road, Stafford, ST16 3EH Tel: 0785 57755	Outdoor acrylic sealant	All-purpose silicone sealant	Expanding filler	—
Unibond, Winsford, Cheshire, CW7 3QY	All-purpose sealant	General-purpose silicone sealant	—	EVA admixture
Swish Products, Tamworth, Staffs, B79 7TW	Acrylic gap filler	Silicone sealant	—	—
Vallance Co, Bruncliffe Avenue, Marley, Leeds, LS27 0LL Tel: 0532 537211	Acrylic sealant	Building silicone sealant	—	—
Cement-Beavor, Tingewick Road, Buckingham, Bucks Tel: 0280 823823	—	—	Expanding foam filler	—
Polycell Products, Welwyn Garden City, Herts, AL7 3AZ	—	—	Expanding foam	—
J Manger & Son, Wollaston Road, Irchester, Northants	—	—	Fill, fix foam	—
Ronacrete Ltd, Selinas Lane, Dagenham, Essex, RM8 1QL Tel: 081 593 7621	—	—	—	Ronafix SBR Repair admixture
Feb Ltd, Swinton Hall Road, Swinton, Manchester, M27 1DT Tel: 061 794 7411	—	—	Endura Flex UR	Febond SBR
Snowcem Plc, Therapia Lane, Croydon, CR9 4EY	—	—	—	Snowcem SBR
Do It All, DIY Stores Throughout the country (Own brand)	Kitchen and bath acrylic sealant	All-purpose silicone sealant	—	—
Texas, DIY Stores Throughout the country (Own brand)	Flexible acrylic sealant	—	—	—

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