INSULATION OF SLAB-ON-GROUND FLOORS

Understanding how to maximise the insulation of a slab-on-ground floor is an important step to designing an energy-efficient building. So, where is the main heat loss, and how is a slab best insulated?

By Ian Cox-Smith, BRANZ Building Physicist

A recent caller to the BRANZ helpline asked why the BRANZ *House insulation guide* does not include examples of a slab-on-ground floor insulated using either polystyrene under the entire floor slab or a much thicker layer of insulation.

The answer is simply that the thermal performance achieved is essentially the same as only adding insulation under the floor slab for the first 1.2 m from the edges. That example is included in the *House insulation guide*.

Thermal resistance does not improve significantly by extending insulation from a perimeter of 1.2 m to the full depth, or by increasing its thickness, The reason being that, with no insulation on the perimeter foundations, most of the heat is conducted along the slab and out through the exterior face of the footing (see Figures 1–3).

Insulate exterior of footing or add themal break

For buildability, it is usual to cover the underside of the entire slab with 50 mm thick polystyrene. To make the best use of insulation under the full depth, there needs to be either:

- a thermal break where the outer edge of the slab joins the perimeter footing (see Figure 4). Details of this were given in *Build* 100 June/July 2007, pages 32–33 and 103–105
- additional insulation applied, and protected, to the exterior face of the footing (see Figure 5).

The same also applies when increasing the thickness of the insulation (see Figure 6). There needs to be either exterior insulation (see Figure 7) or a thermal break to get the best out of the extra insulation material. In practice, floors are never constructed as in Figures 6 and 7, but the example illustrates the relatively small impact that this substantial increase in thickness of insulation (R6) has on the thermal performance.

Thermal models

Figures 1–7 show the results of thermal modelling a simple 10 m by 10 m square floor slab, with an area (A) to perimeter length (P) of 100/40 = 2.5. Because the ground under a slab provides insulation, the primary heat flow path is through the perimeter of the slab. The higher the A/P value, the greater the thermal resistance. This means that larger slabs perform thermally better than smaller slabs.

The coloured areas in the figures represent heat flow – red is higher heat flow and blue is lower heat flow. The total heat loss depends on both the intensity (represented by the colour) and the area (shown by the size of the coloured area) of heat flow. The areas of lowest heat flow are not coloured.

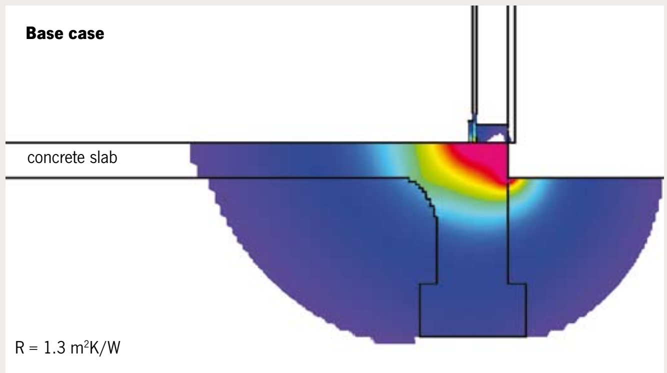

Figure 1: Plain slab (A/P ratio = 2.5, e.g. 10 m x 10 m).

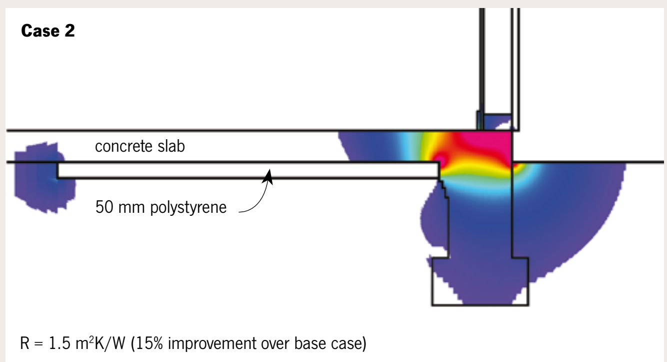

Figure 2: 50 mm polystyrene for the first 1.2 m width under edge of slab.

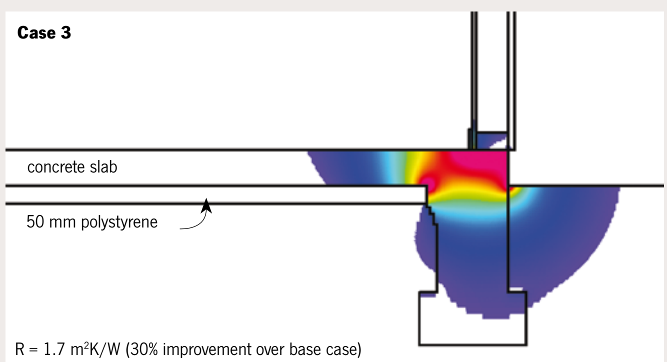

Figure 3: 50 mm polystyrene under full depth (5 m) of slab (but not under foundation footing).

Not all changes improve performance

Examination of the modelling results highlights the impact of changes in design.

BASE CASE

This represents the most common construction. Without insulation, this has a large area of high heat flow (red) at the exterior edge of the slab and the largest area of heat flow (colour).

SMALL IMPROVEMENTS

Case 2 represents a 15% improvement in the thermal resistance, but the addition of 50 mm of polystyrene with R1.2 has only added R0.2 overall. The area of highest heat flow is similar, but the total coloured area is less.

Case 3 is similar to case 2 except for the absence of heat flow around the inner end of the insulation. Doubling the area of insulation has resulted in a further 15% improvement but only another R0.2 in absolute terms.

BIG IMPROVEMENT WITH THERMAL BREAK

Case 4 shows that, with the further addition of a thermal break, the overall improvement of R1.0 is approaching the R-value of the insulation layer that has been added (R1.2). If the thermal break was made from polystyrene, rather than timber, the overall improvement would be equivalent to the R-value of the 50 mm polystyrene material.

Case 5 is an alternative to case 4 and results in the same overall improvement (R1.0). Again, if the R-value of the insulation added to the outside of the footing was similar to that of the 50 mm polystyrene material, then the effect would be an overall improvement of R1.2. The restriction is the visual impact where the insulation is above ground level, hence the use of extruded polystyrene to limit the thickness of insulation needed.

THICKER INSULATION

Case 6 demonstrates how, without a thermal break or thermal protection to the slab edge, the use of 250 mm of insulation (R6) achieves only slightly more (R0.1) than the result for the 50 mm thick insulation layer (R1.2) in case 2. Note this is not how the floor would be constructed in practice.

Case 7 represents a significant improvement in the R-value and almost the same result as for cases 4 and 5. Again, this is not how the floor would be constructed in practice.

CODE COMPLIANCE

Only cases 4, 5 and 7 would provide sufficient thermal resistance to meet the Building Code requirements for heated floor slabs.

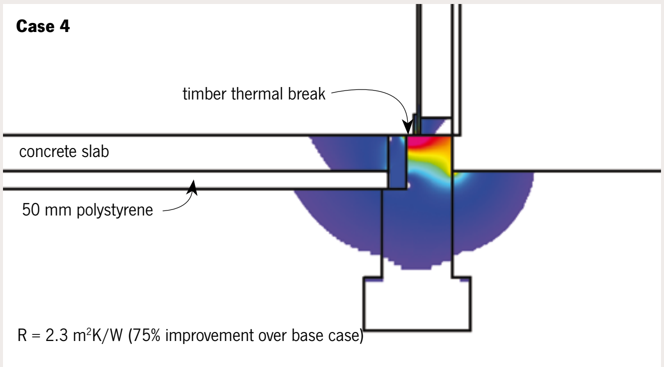

Figure 4: 50 mm polystyrene plus 45 mm wide timber thermal break at the inner edge of the slab.

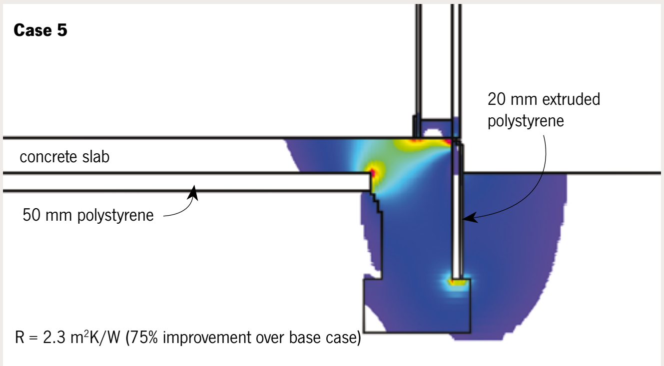

Figure 5: 50 mm polystyrene plus 20 mm extruded polystyrene to exterior face of footing.

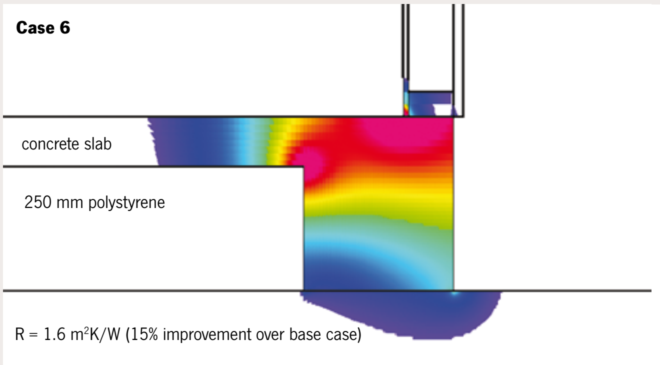

Figure 6: 250 mm thick polystyrene.

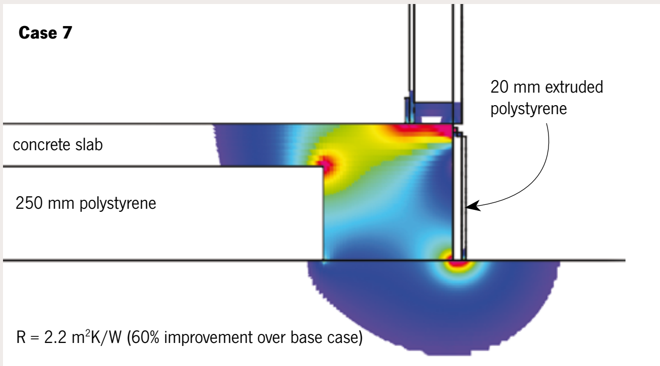

Figure 7: 250 mm thick polystyrene with 20 mm extruded polystyrene to exterior edge of slab.