

Assessing the effects of thermal bridging at junctions and around openings

IP 1/06

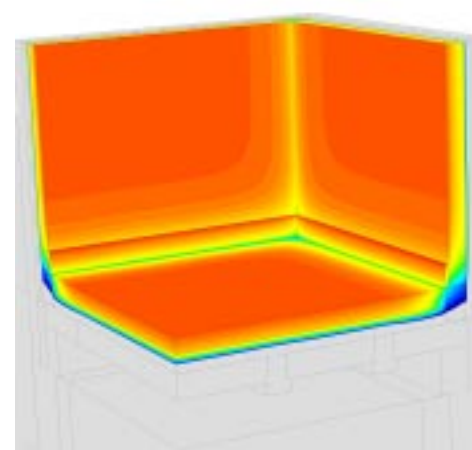
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This paper gives guidance on assessing the effects of thermal bridging at junctions and around openings in the external elements of buildings and how to assess their effect on the overall heat loss (or heat gain). It enables a satisfactory estimate of these heat transfers to be made for the purposes of carrying out building regulations compliance calculations. It supports the building regulations for the conservation of fuel and power in all three jurisdictions within the UK. The guidance is primarily intended for junction and opening details that are **not** as recommended in *Accredited construction details* or MCRMA/EPIC guidance.

It is assumed that the reader has an understanding of the principles, and familiarity with the calculation, of the fabric heat loss through the plane external elements of buildings.

This paper is a revision of IP17/01 which is now withdrawn.



1 Introduction

In general, thermal bridges can occur at any junction between building elements or where the building structure changes. Reduced internal surface temperature and increased heat loss, compared with that of the unbridged structure, are the two primary effects associated with a thermal bridge where a building is being heated. Consequently there is an increased risk of condensation and mould growth at the thermal bridge and a significant additional heat loss through the thermal bridge.

Thermal bridges fall into two categories:

- (a) Repeating thermal bridges (such as timber joists, mortar joints, and mullions in curtain walling). The additional heat flow due to the presence of this type of thermal bridge is included in the determination of the U-value of the particular building element which contains these bridges (for further details see BR 443^[1])

- (b) Non-repeating thermal bridges (such as junctions of floor and roof with the external wall, and details around window and door openings) where the additional heat flow due to the presence of this type of thermal bridge is determined separately

This paper deals only with type (b). It gives guidance on limiting the risk of surface condensation and mould growth at these thermal bridges. It describes how to assess their thermal performance and how to incorporate the additional heat loss through such thermal bridges in calculations of the performance of the building fabric as a whole.

Note

The heat loss through the frame of the door or window in an opening is accounted for in the U-value of the door or window.

2 Building Regulations^[2,3,4]

Building regulations for the conservation of fuel and power indicate that provision should be made to limit thermal bridging at junctions and around openings in order to avoid excessive heat losses (or gains) and the possibility of local condensation problems in heated buildings. One way of demonstrating that such provision has been made is to use the details in *Accredited construction details*^[5] or MCRMA/EPIC guidance^[6].

In other cases thermal bridges should be assessed by numerical modelling.

3 Numerical modelling

BS EN ISO 10211^[7] sets out criteria for carrying out numerical calculations, covering both three- and two-dimensional numerical modelling of building details. It provides specifications of the geometrical model and boundary conditions together with accuracy criteria for the solution technique adopted. It gives methods for the calculation of heat flows and surface temperatures and includes the method for deriving linear thermal transmittance values. Guidance on appropriate modelling techniques is in preparation^[8].

3.1 Calculating the temperature factor

For a specific detail, three-dimensional modelling can be used to calculate the temperature factor f_{Rsi} of the location(s) of the lowest internal surface temperature (see section 4). Simpler two-dimensional modelling of the building detail can, in many cases, be used where any three-dimensional effects arise solely from the intersection of two or more two-dimensional models, ie where the intersection itself does not contain a constructional 'point' thermal bridge. One exception, however, is the corner of a ground floor, where the modelling to determine the temperatures must be three-dimensional.

3.2 Calculating linear thermal transmittance (Ψ)*

The linear thermal transmittance of junctions (see section 5) is obtained from the total calculated heat flow through a two-dimensional model by subtracting the one-dimensional heat flow through the plane building elements. It therefore represents the additional heat flow associated with the junction, over and above that obtained from

* Note that point thermal transmittances (χ -values), arising from the intersection of two or more two-dimensional junctions, are ignored, unless (in addition to the geometrical point thermal bridge) there is an important constructional thermal bridge (eg penetration of insulation by a metal component).

the U-values and areas of the plane elements. It is important therefore to use the correct dimensions (within the numerical model) over which the U-value of the plane elements is considered to apply, in order to subtract the correct one-dimensional heat flow when calculating Ψ . From BS EN ISO 10211^[7], the linear thermal transmittance is calculated from:

$$\Psi = L^{2D} - \sum_{j=1}^n U_j l_j$$

where L^{2D} = the total heat flow through the two-dimensional numerical model

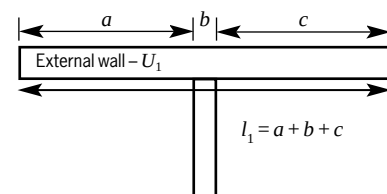
U_j = the U-value of the plane building element j

l_j = the length (in the two-dimensional model) over which U_j applies

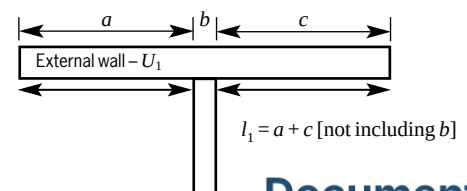
Use of the correct dimension for l_j is illustrated in Examples 1 and 2 by way of two similar junctions, for which the calculated Ψ -values for the two cases are distinctly different. Example 1 illustrates in plan the junction of an external wall with an internal partition, and Example 2 illustrates in plan the junction of an external wall with a party wall (ie a wall separating different premises).

The two different lengths for l_j arise from the different areas over which the U-value is applied. In the Building Regulations the U-value applies 'between finished internal faces of the external elements of the building', ie ignoring partition walls and intermediate floors of the same premises, but not the separating walls or floors between different premises. Thus the Ψ -value depends not only on the specific construction of the junction, but also on the area over which the relevant U-values are being applied.

Example 1 Junction of external wall with an internal partition wall



Example 2 Junction of external wall with an internal party wall



3.3 Numerical modelling of details around openings

When determining the linear thermal transmittance (Ψ) of a detail around an opening, the boundary in the model, where the frame of the window or door connects with the opening, is taken to be adiabatic, that is the heat flow across this boundary is considered to be zero. Therefore, the Ψ -value for an opening is independent of the properties of the window frame, and depends only on the location of the frame in the opening and its dimension (where it connects to the opening detail). However, when determining internal surface temperatures (and hence the temperature factor), strictly, the opening details should be re-modelled with the window or door and its frame in place. This can be done where the window or door construction to be used is known. Often, however, the performance of such details needs to be determined when the window or door to be used is unknown (or might vary). For the purposes of Building Regulations, the assessment of internal surface temperatures, and hence temperature factor, may be determined using the same adiabatic connection as used when determining the linear thermal transmittance, $\Psi^\dagger$.

4 Limiting the risk of surface condensation or mould growth

To assess the risk of surface condensation or mould growth for a specific detail, the minimum internal surface temperature (for specified internal and external environments) is required. Under steady-state conditions the temperature factor f_{Rsi} is defined by:

$$f_{\text{Rsi}} = \frac{T_{\text{si}} - T_{\text{e}}}{T_{\text{i}} - T_{\text{e}}}$$

where T_{si} = minimum internal surface temperature

T_{i} = internal temperature

T_{e} = external temperature

The temperature factor is, therefore, a property of the construction. To limit the risk of surface condensation or mould growth, f_{Rsi} should be greater than or equal to a critical value (f_{CRsi}). This critical value depends upon the internal and external environments and applies generally to the whole of the internal surface. However, for three-dimensional corners of ground floors, even with good designs, the internal surface temperature (because of the geometry of the three-dimensional corner) dips steeply. Therefore the area over which the internal surface temperature is less than the critical temperature is usually small. It is appropriate in such cases to have a relaxation (g) of the critical temperature factor f_{CRsi} to f'_{CRsi} , coupled with a relaxation in distance from the coldest point. So:

$$f'_{\text{CRsi}} = g \times f_{\text{CRsi}}$$

and the condition to avoid surface condensation or mould growth becomes:

$$f_{\text{Rsi}} \geq f'_{\text{CRsi}}$$

for all points that are a distance of d mm or more from the point(s) with the lowest f_{Rsi} . For three-dimensional corners of ground floors only, $d = 10$ mm and $g = 0.93$. For all other details these relaxations do not apply.

[†] If, however, a more refined assessment of the temperature factor is required, and the window or door to be used (including the frame) is known, then the window or door and its frame should be included in the re-modelling, from which the more refined temperature factor can be determined.