

Thermal bridges in building construction — Calculation of heat flows and surface temperatures —

Part 1: General methods

The European Standard EN ISO 10211-1:1995 has the status of a British Standard

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Committees responsible for this British Standard

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Association of Building Component Manufacturers
Association for the Conservation of Energy
Association of Lightweight Aggregate Manufacturers
Autoclaved Aerated Concrete Products Association
Brick Development Association
British Rigid Urethane Foam Manufacturers' Association
British Vermiculite Association
Building Employers' Confederation
Cavity Foam Bureau
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Department of the Environment (Building Research Establishment)
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Department of Trade and Industry (National Physical Laboratory)
Eurisol (UK Mineral Wool Association)
European Phenolic Foam Association
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Meteorological Office
National House-building council
Polyethylene Foam Insulation Association
Thermal Insulations Contractors' Association
Thermal Insulation Manufacturers' and Suppliers' Association (TIMSA)
Wood Wool Slab Manufacturers' Association

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National foreword

This British Standard has been prepared by Technical Committee B/540/1 and is the English language version of EN ISO 10211-1:1995 *Thermal bridges in building construction — Heat flows and surface temperatures — Part 1: General calculation methods*, including Corrigendum April 2002, published by the European Committee for Standardization (CEN). It is identical with ISO 10211-1:1995 published by the International Organization for Standardization (ISO).

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Summary of pages

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English version

Thermal bridges in building construction — Calculation of heat flows and surface temperatures — Part 1: General methods

(ISO 10211-1:1995)

Ponts thermiques dans les bâtiments—
Calcul des flux thermiques et des températures
superficielles —
Partie 1: Méthodes générales
(ISO 10211-1:1995)

Wärmebrücken im Hochbau — Berechnung der
Wärmerströme und Oberflächentemperaturen —
Teil 1: Allgemeine Verfahren
(ISO 10211-1:1995)

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European Committee for Standardization
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Central Secretariat: rue de Stassart 36, B-1050 Brussels

Foreword

The text of EN ISO 10211-1:1995 has been prepared by Technical Committee CEN/TC 89, Thermal performance of buildings and building components, in collaboration with ISO/TC 163, Thermal insulation.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by February 1996, and conflicting national standards shall be withdrawn at the latest by December 2001.

According to CEN/CENELEC Internal Regulations, the following countries are bound to implement this European Standard: Austria, Belgium, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and the United Kingdom.

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Introduction

Thermal bridges, which in general occur at any junction between building components or where the building structure changes composition, have two consequences:

- a) a change in heat flow rate; and
 - b) a change in internal surface temperature
- compared with those of the unbridged structure.

Although similar calculation procedures are used, the procedures are not identical for the calculation of heat flows and of surface temperatures.

Usually a thermal bridge gives rise to 3-dimensional or 2-dimensional heat flows, which can be precisely determined using detailed numerical calculation methods as described in this standard. These are termed “Class A” methods, and Part 1 of this standard lays down criteria which have to be satisfied in order that a method can be described as being “Class A”.

In many applications numerical calculations which are based on a 2-dimensional representation of the heat flows provide results with an adequate accuracy. These are termed “Class B” methods. Part 2 of this standard lays down criteria for the calculation of linear thermal bridges which have to be satisfied in order that the calculation method can be described as being “Class B”.

Other less precise but much simpler methods, which are not based on numerical calculation may provide adequate assessment of the additional heat loss caused by thermal bridges. Simplified methods are given in EN ISO 14683, Thermal bridges in building construction — Linear thermal transmittance — Simplified methods and default values (ISO 14683).

1 Scope

Part 1 of this standard sets out the specifications on a 3-D and 2-D geometrical model of a thermal bridge for the numerical calculation of:

- heat flows in order to assess the overall heat loss from a building;
- minimum surface temperatures in order to assess the risk of surface condensation.

These specifications include the geometrical boundaries and subdivisions of the model, the thermal boundary conditions and the thermal values and relationships to be used.

The standard is based upon the following assumptions:

- steady-state conditions apply;
- all physical properties are independent of temperature;
- there are no heat sources within the building element.

It may also be used for the derivation of linear and point thermal transmittances and of surface temperature factors.

2 Normative references

This standard incorporates by dated and undated reference, provisions from other publications. These normative references are cited at the appropriate places in the text and the publications are listed hereafter. For dated references, subsequent amendments to or revisions of any of these publications apply to this standard only when incorporated in it by amendment or revision. For undated references the latest edition of the publication referred to applies.

ISO 7345, *Thermal insulation — Physical quantities and definitions*.

EN 673, *Glass in building — Determination of the thermal transmittance (U-value) — Calculation method*.

EN ISO 6946-1, *Building components and building elements — Part 1: Thermal resistance and thermal transmittance — Calculation method* (ISO 6946)

EN ISO 10456, *Thermal insulation — Building materials and products — Determination of declared and design values* (ISO 10456).

EN ISO 13789, *Thermal performance of buildings — Transmission heat loss coefficient — Calculation method* (ISO 13789).

3 Definitions and symbols

3.1 Definitions

For the purposes of this standard, the definitions of ISO 7345 and the following definitions apply:

- 3.1.1**
thermal bridge
part of the building envelope where the otherwise uniform thermal resistance is significantly changed by:
- a) full or partial penetration of the building envelope by materials with a different thermal conductivity and/or
 - b) a change in thickness of the fabric and/or
 - c) a difference between internal and external areas, such as occur at wall/floor/ceiling junctions

- 3.1.2**
3-D geometrical model
geometrical model, deduced from building plans, such that for each of the orthogonal axes, the cross-section perpendicular to that axis changes within the boundary of the model (see Figure 1)

- 3.1.3**
3-D flanking element
part of the 3-D geometrical model which, when considered in isolation, can be represented by a 2-D geometrical model (see Figure 1 and Figure 2)

- 3.1.4**
3-D central element
part of the 3-D geometrical model which is not a 3-D flanking element (see Figure 1)

- 3.1.5**
2-D geometrical model
geometrical model deduced from building plans, such that for one of the orthogonal axes, the cross-section perpendicular to that axis does not change within the boundaries of the model (see Figure 2)

NOTE A 2-D geometrical model is used for two-dimensional calculations.

- 3.1.6**
construction planes
planes in the 3-D or 2-D model which separate:
- different materials;
 - the geometrical model from the remainder of the construction;
 - the flanking elements from the central element. (see Figure 3).

- 3.1.7**
cut-off planes
those construction planes that are boundaries to the 3-D model or 2-D model by separating the model from the remainder of the construction (see Figure 3)

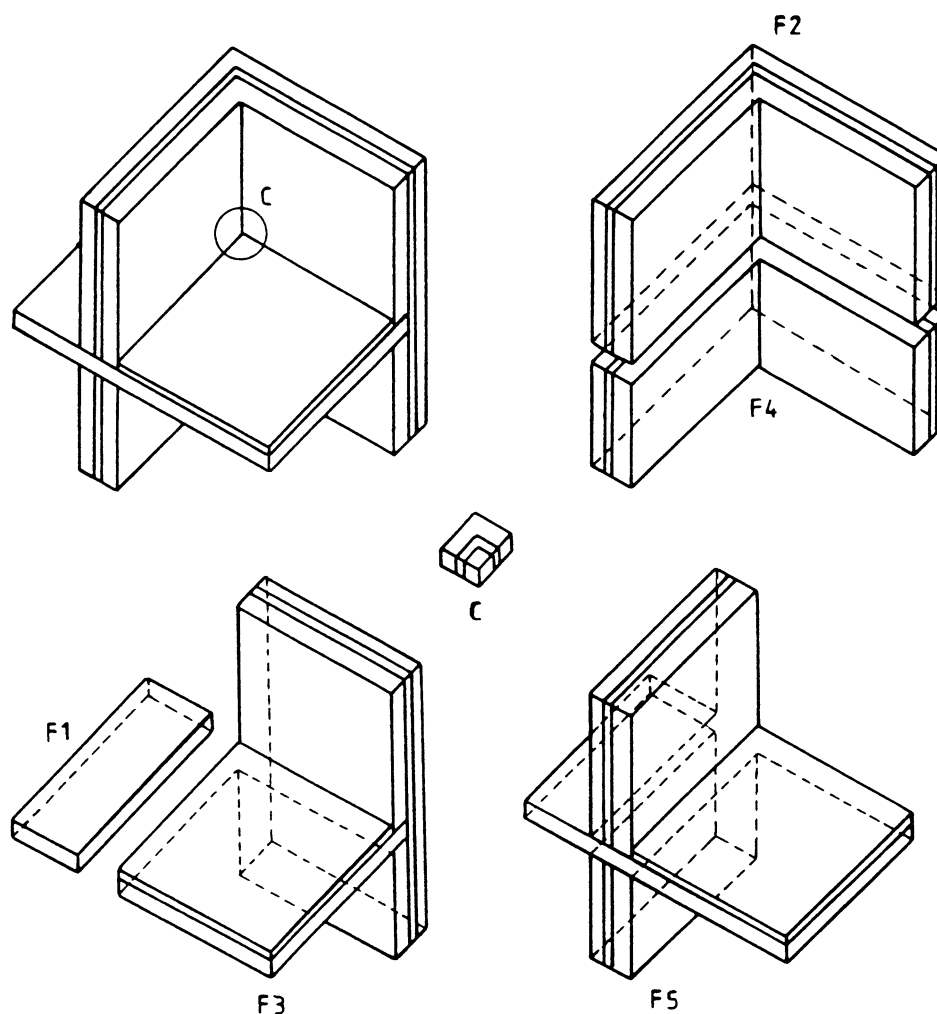


Figure 1 — 3-D model with five 3-D flanking elements and one 3-D central element. F1 to F5 have constant cross-sections perpendicular to at least one axis. C is the remaining part

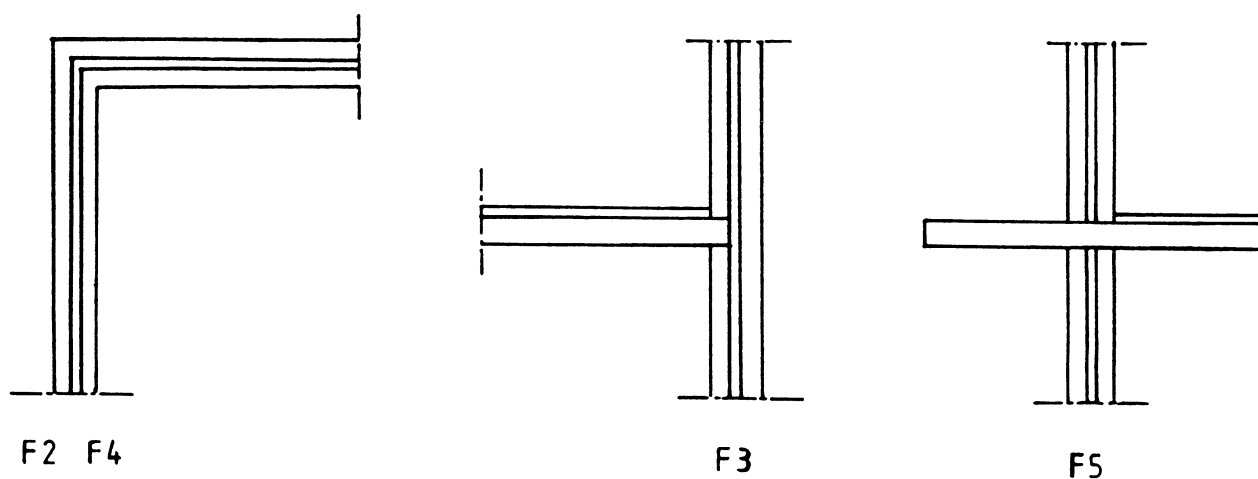


Figure 2 — The cross-sections of the flanking elements in a 3-D model can be treated as 2-D models. F2 to F5 refer to Figure 1

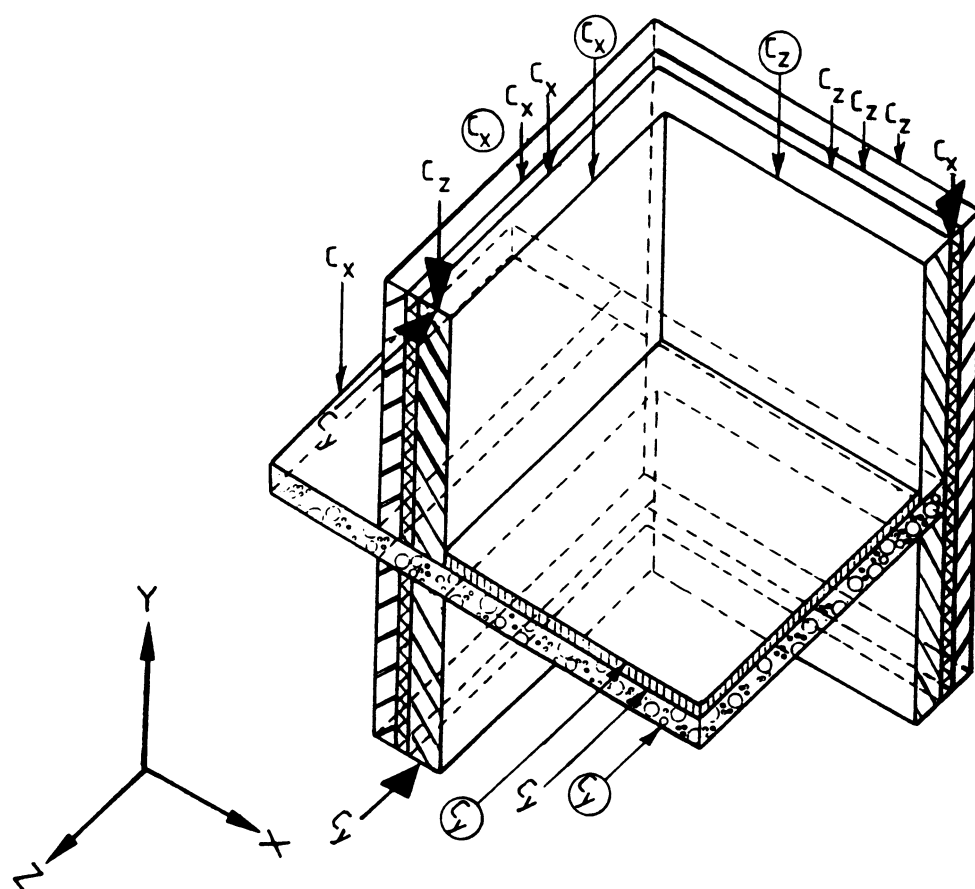


Figure 3 — Example of a 3-D model showing construction planes
 C_x are construction planes perpendicular to the x-axis
 C_y are construction planes perpendicular to the y-axis
 C_z are construction planes perpendicular to the z-axis
 Cut-off planes are indicated with enlarged arrows. Planes that separate flanking elements from the central element are encircled.

3.1.8

auxiliary planes

planes which, in addition to the construction planes, divide the geometrical model into a number of cells

3.1.9

quasi-homogeneous layer

layer which consists of two or more materials with different thermal conductivities, but which can be considered as a homogeneous layer with an effective thermal conductivity (see Figure 4)

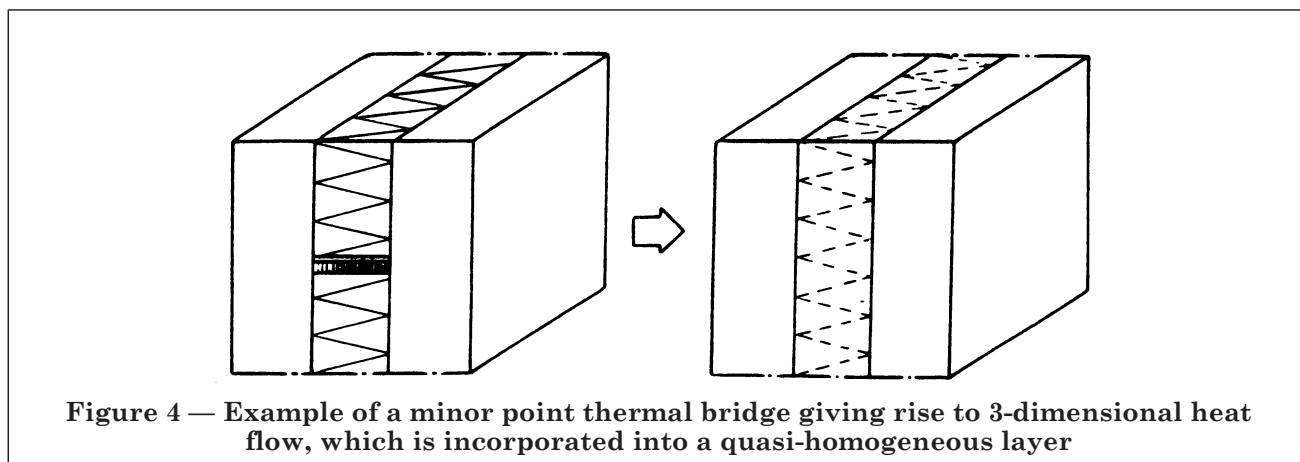


Figure 4 — Example of a minor point thermal bridge giving rise to 3-dimensional heat flow, which is incorporated into a quasi-homogeneous layer

3.1.10

temperature difference ratio, ζ_{Rsi}

difference between the internal air temperature and the temperature of the internal surface, divided by the difference between the internal air temperature and the external air temperature, calculated with a surface resistance R_{si} at the internal surface

3.1.11

temperature factor at the internal surface, f_{Rsi}

difference between the temperature of the internal surface and the external air temperature, divided by the difference between the internal air temperature and the external air temperature, calculated with a surface resistance R_{si} at the internal surface

NOTE $f_{Rsi} = 1 - \zeta_{Rsi}$.

3.1.12

temperature weighting factor, g

factor which states the relative influence of the air temperatures of the thermal environments upon the surface temperature at the point under consideration

3.1.13

external reference temperature

external air temperature, assuming that the sky is completely overcast

3.1.14

internal reference temperature

- a) dry resultant temperature in the room under consideration.
- b) mean value of the internal air temperature in the room under consideration.

NOTE 1 a) is used when calculating heat flows in order to assess the overall heat loss and b) is used when calculating surface temperatures in order to assess the risk of surface condensation.

NOTE 2 For calculation purposes the reference temperature is considered to be uniform throughout the internal environment.

3.1.15

dry resultant temperature

the arithmetic mean value of the internal air temperature and the mean radiant temperature of all surfaces surrounding the internal environment

3.1.16

thermal coupling coefficient, L_{ij}

heat flow per unit temperature difference between two environments i, j which are thermally connected by the construction under consideration

3.1.17

linear thermal transmittance, ψ

correction term for the linear influence of a thermal bridge when calculating the thermal coupling coefficient L from 1-D calculations

3.1.18

point thermal transmittance, χ

correction term for the point influence of a thermal bridge when calculating the thermal coupling coefficient L from 1-D calculations

3.2

Symbols and units

Symbol	Physical quantity	Unit
A	area	m^2
H	height	m
L	thermal coupling coefficient	W/K
R	thermal resistance	$\text{m}^2 \cdot \text{K}/\text{W}$
R_{se}	external surface resistance	$\text{m}^2 \cdot \text{K}/\text{W}$
R_{sl}	internal surface resistance	$\text{m}^2 \cdot \text{K}/\text{W}$
T	thermodynamic temperature	K
U	thermal transmittance	$\text{W}/(\text{m}^2 \cdot \text{K})$
V	volume	m^3
b	width	m
d	thickness	m
f_{Rsi}	temperature factor at the internal surface	—
g	temperature weighting factor	—
h	heat transfer coefficient	$\text{W}/(\text{m}^2 \cdot \text{K})$
l	length	m
q	density of heat flow rate	W/m^2
θ	Celsius temperature	$^{\circ}\text{C}$
$\Delta\theta$	temperature difference	K
λ	thermal conductivity	$\text{W}/(\text{m} \cdot \text{K})$
ζ_{Rsi}	temperature difference ratio	—
Φ	heat flow rate	W
χ	point thermal transmittance	W/K
ψ	linear thermal transmittance	$\text{W}/(\text{m} \cdot \text{K})$

List of subscripts

cav	cavity
dp	dewpoint
e	exterior
i	interior
l	Linear
min	minimum
s	surface

4 Principles

The *temperature* distribution in and the *heat flow* through a construction can be calculated if the boundary conditions and constructional details are known. For this purpose, the geometrical model is divided into a number of adjacent material cells, each with a homogeneous thermal conductivity. The criteria which shall be met when constructing the model are given in Clause 5.

In Clause 6 instructions are given for the determination of the values of thermal conductivity and boundary conditions.

The temperature distribution is determined either by means of an iterative calculation or by a direct solution technique, after which the temperature distribution within the material cells is determined by interpolation.

The calculation rules and the method of determining the temperature distribution are described in Clause 7.

NOTE Some of the following clauses contain differences between the calculation of surface temperatures and the calculation of heat flows; the differences are given in Table 1, Table 3 and Table 4.

5 Modelling of the construction

5.1 Rules for modelling

It is not usually feasible to model a complete building using a single geometrical model. In most cases the building may be partitioned into several parts (including the subsoil where appropriate) by using cut-off planes. This partitioning shall be performed in such a way that any differences in calculation result between the partitioned building and the building when treated as a whole is avoided.

This partitioning into several geometrical models is achieved by choosing suitable cut-off planes.

5.1.1 Cut-off planes of the geometrical model

The geometrical model includes the central element(s), the flanking elements and where appropriate the subsoil. The geometrical model is delimited by cut-off planes.

Cut-off planes shall be positioned as follows:

- at a symmetry plane if this is less than 1 m from the central element (see Figure 5);
- at least 1 m from the central element if there is no nearer symmetry plane;
- in the subsoil according to Table 1.

NOTE If there is more than one thermal bridge present in the geometrical model, the calculated surface temperature at the central element of the second thermal bridge is only correct if the second thermal bridge is at a distance of at least 1 m from the nearest cut-off plane (see Figure 6), unless the cut-off plane is a symmetry plane.

Dimensions in mm

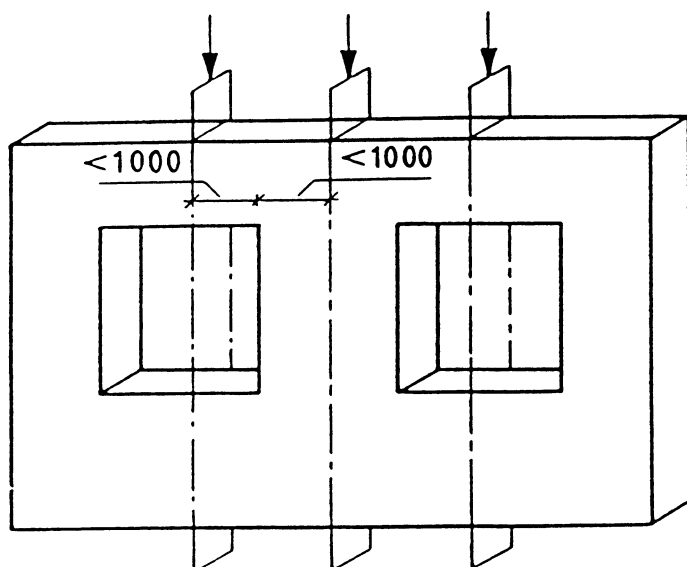


Figure 5 — Symmetry planes which can be used as cut-off planes

Dimensions in mm

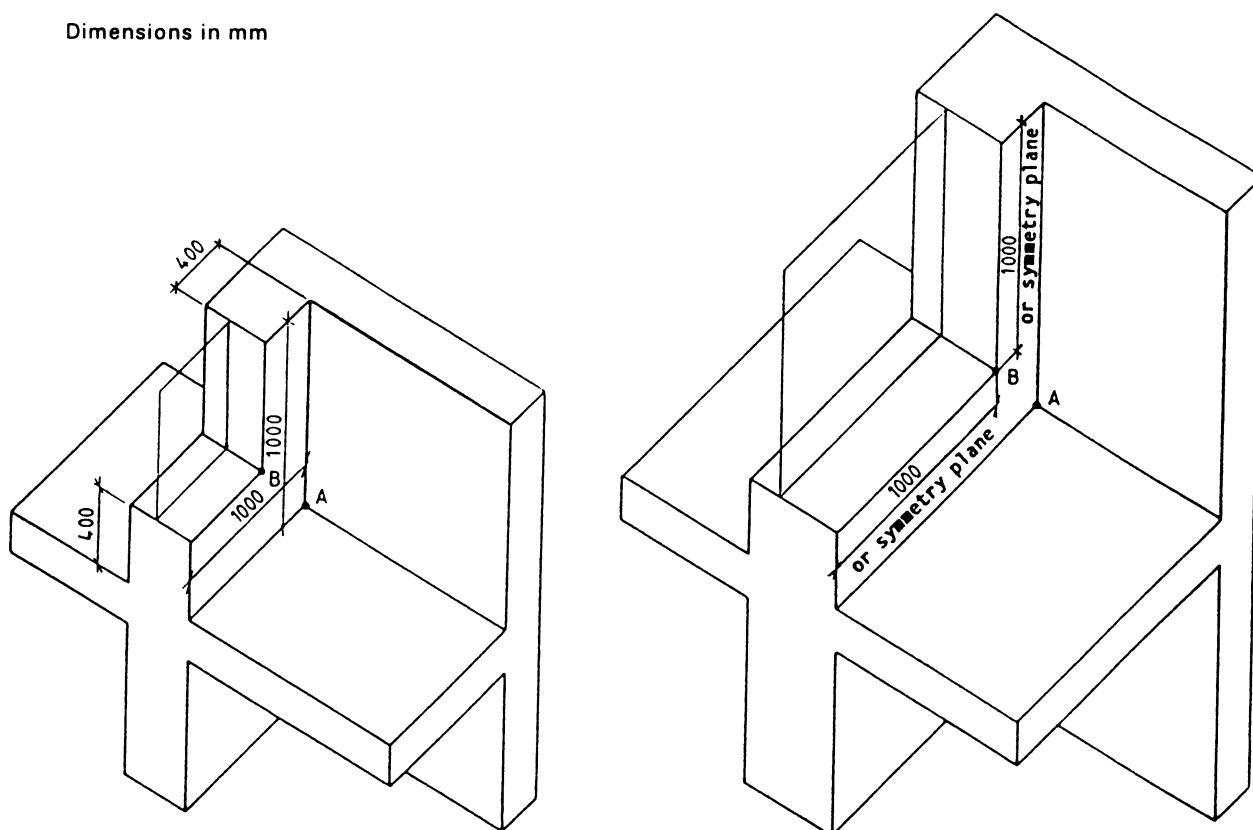


Figure 6 — Two thermal bridges A and B in the same model. The thermal bridge nearest to the cut-off planes does not fulfil the condition of being at least 1 m from a cut-off plane (left). This difficulty is avoided by extending the model in two directions (right)

Table 1 — Location of cut-off planes in the subsoil
(foundations, ground floors, basements)

Direction	Purpose of the calculation	
	Surface temperatures, see Figure 7a	heat flow, see Figure 7b
Horizontal inside the building	at least 1 m	0,5 b
Horizontal outside the building	same distance as inside the building	2,5 b
Vertical below ground level	3 m	2,5 b
Vertical below floor level (see Note)	1 m	—
where		
b is the width (the smaller dimension) of the ground floor in metres.		

NOTE This value applies only if the level of the floor under consideration is more than 2 m below the ground level.