INTERNATIONAL STANDARD

ISO 10211-1

First edition
1995-08-15

Thermal bridges in building construction — Heat flows and surface temperatures —

Part 1:
General calculation methods

Ponts thermiques dans le bâtiment — Flux de chaleur et températures superficielles —
Partie 1: Méthodes générales de calcul

Reference number
ISO 10211-1:1995(E)

Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

International Standard ISO 10211-1 was prepared by the European Committee for Standardization (CEN) in collaboration with Technical Committee ISO/TC 163, *Thermal insulation*, Subcommittee SC 2, *Calculation methods*, in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement).

ISO 10211 consists of the following part, under the general title *Thermal bridges in building construction — Heat flows and surface temperatures*:

— *Part 1: General calculation methods*

The following part is in preparation:

— *Part 2: Calculation of linear thermal bridges*

Annexes A, B and C form an integral part of this part of ISO 10211. Annexes D, E, F and G are for information only.

International Organization for Standardization
Case postale 56 • CH-1211 Genève 20 • Switzerland

Printed in Switzerland

CONTENTS

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of an identical text or by endorsement, at the latest by February 1996, and conflicting national standards shall be withdrawn at the latest by February 1996.

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.

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 prEN ISO 14683, Thermal bridges in building constructions - Linear thermal transmittance - Simplified methods and design values (ISO/DIS 14683:1995).

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

prEN 673 Thermal insulation of glazing - Calculation rules for determining the steady state thermal transmittance of glazing

prEN ISO 6946-1 Building components and building elements - Thermal resistance and thermal transmittance - Calculation method

prEN ISO 10456 Thermal insulation - Building materials and products - Determination of declared and design values

prEN ISO 13789 Thermal performance of buildings - Specific transmission heat loss - Calculation method

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 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).

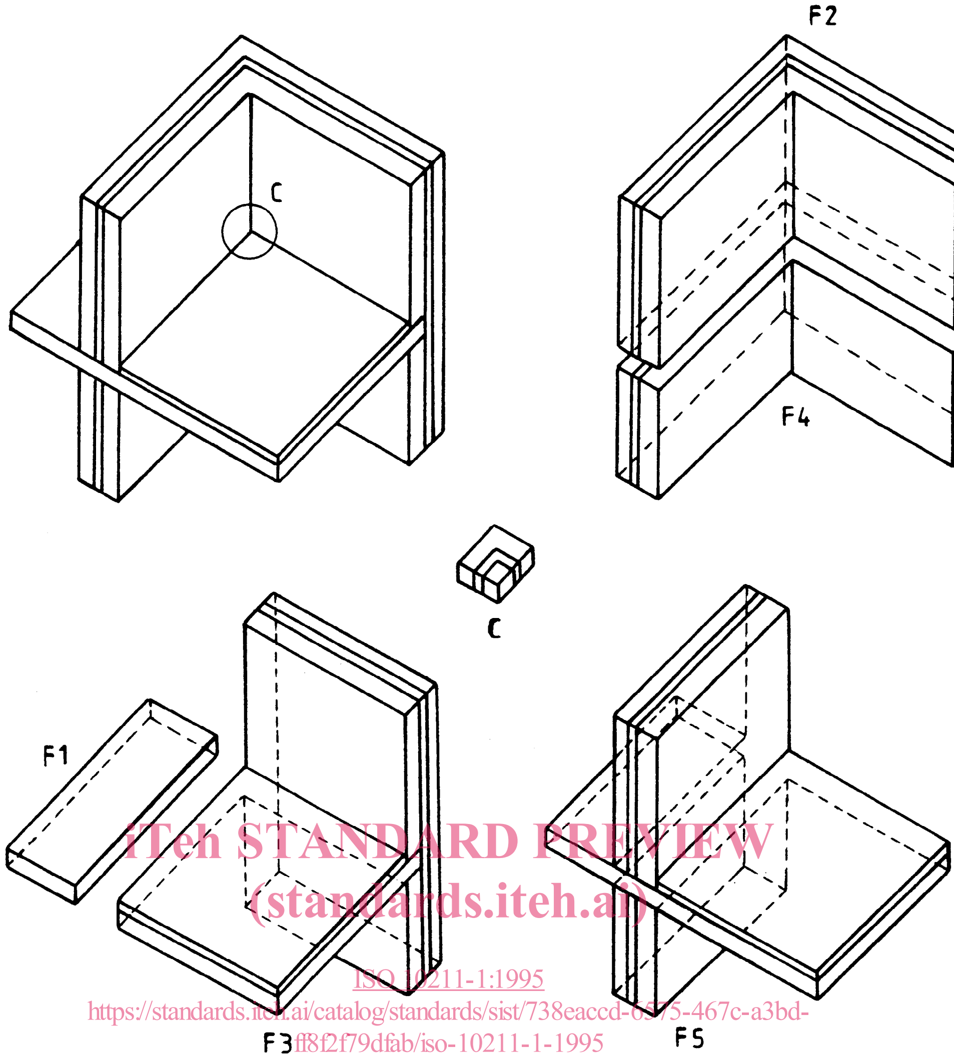


Figure 1: 3-D model with five 3-D flanking elements and one 3-D central element. F1 to F5 have constant cross-sections perpendicular to at least one axis. C is the remaining part

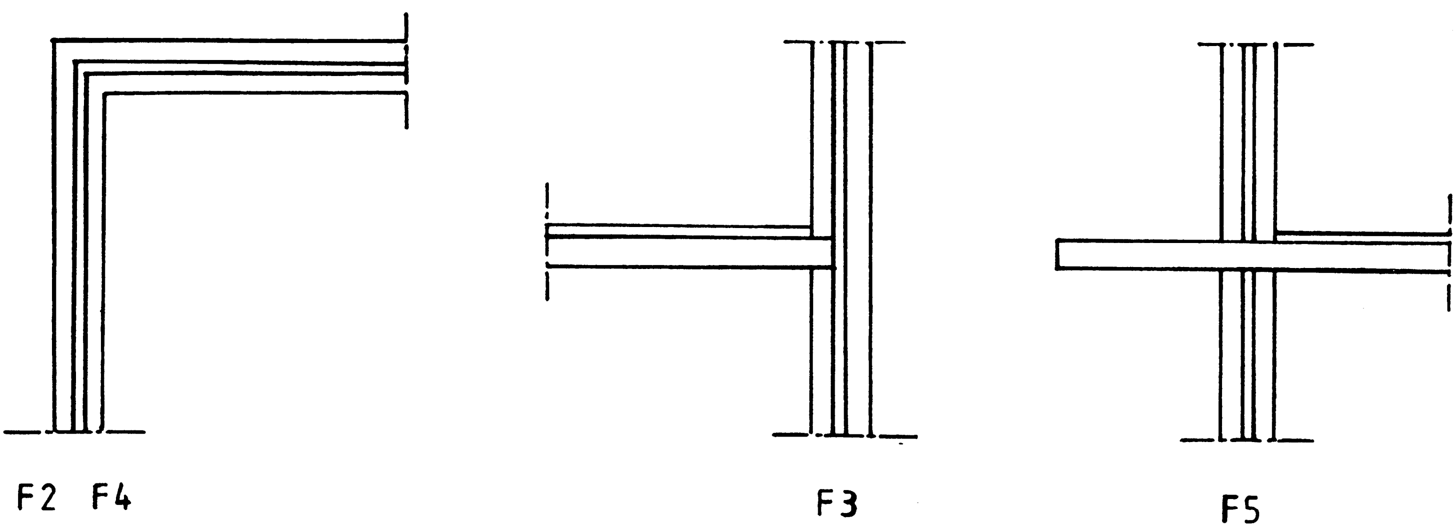


Figure 2: The cross sections of the flanking elements in a 3-D model can be treated as 2-D models. F2 to F5 refer to figure 1.

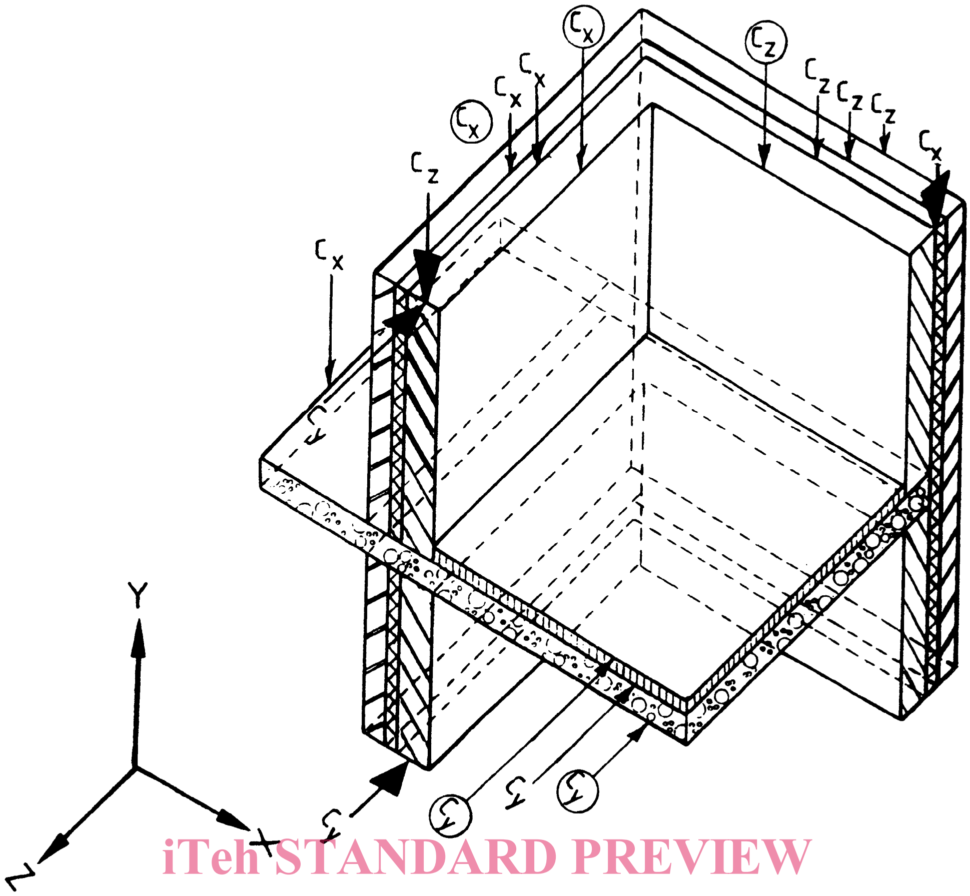


Figure 3: Example of a 3-D model showing construction planes.
C_x are construction planes perpendicular to the x-axis
C_y are construction planes perpendicular to the y-axis
C_z are construction planes perpendicular to the z-axis
Cut-off planes are indicated with enlarged arrows. Planes that separate 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).

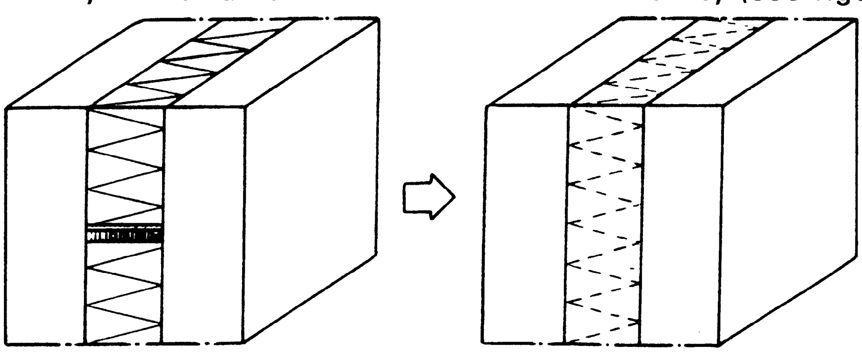


Figure 4: Example of a minor point thermal bridge giving rise to 3-dimensional heat flow, which is incorporated into a quasi-homogeneous layer

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, $L_{i,j}$: 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	$m^2 \cdot K/W$
R_{se}	external surface resistance	$m^2 \cdot K/W$
R_{si}	internal surface resistance	$m^2 \cdot K/W$
T	thermodynamic temperature	K
U	thermal transmittance	$W/(m^2 \cdot K)$
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	$W/(m^2 \cdot K)$
l	length	m
q	density of heat flow rate	W/m^2
θ	Celsius temperature	°C
$\Delta\theta$	temperature difference	K
λ	thermal conductivity	$W/(m \cdot K)$
ζ_{Rsi}	temperature difference ratio	-
Φ	heat flow rate	W
χ	point thermal transmittance	W/K
Ψ	linear thermal transmittance	$W/(m \cdot K)$

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 tables 1, 3 and 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

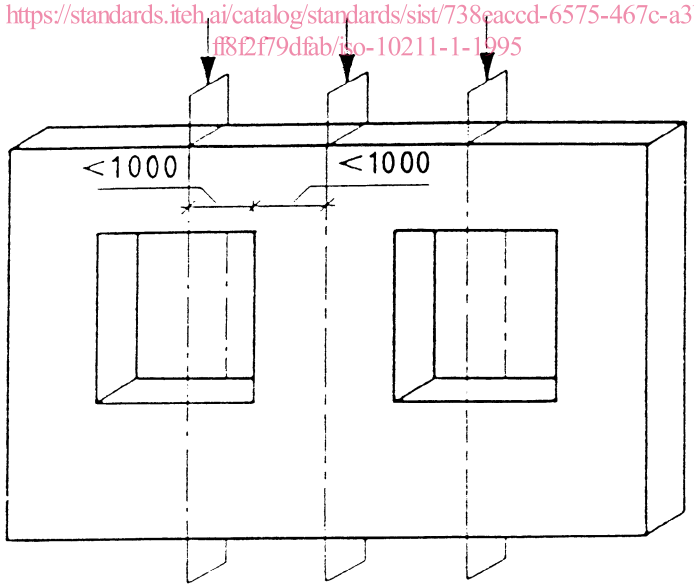


Figure 5: Symmetry planes which can be used as cut-off planes

Dimensions in mm

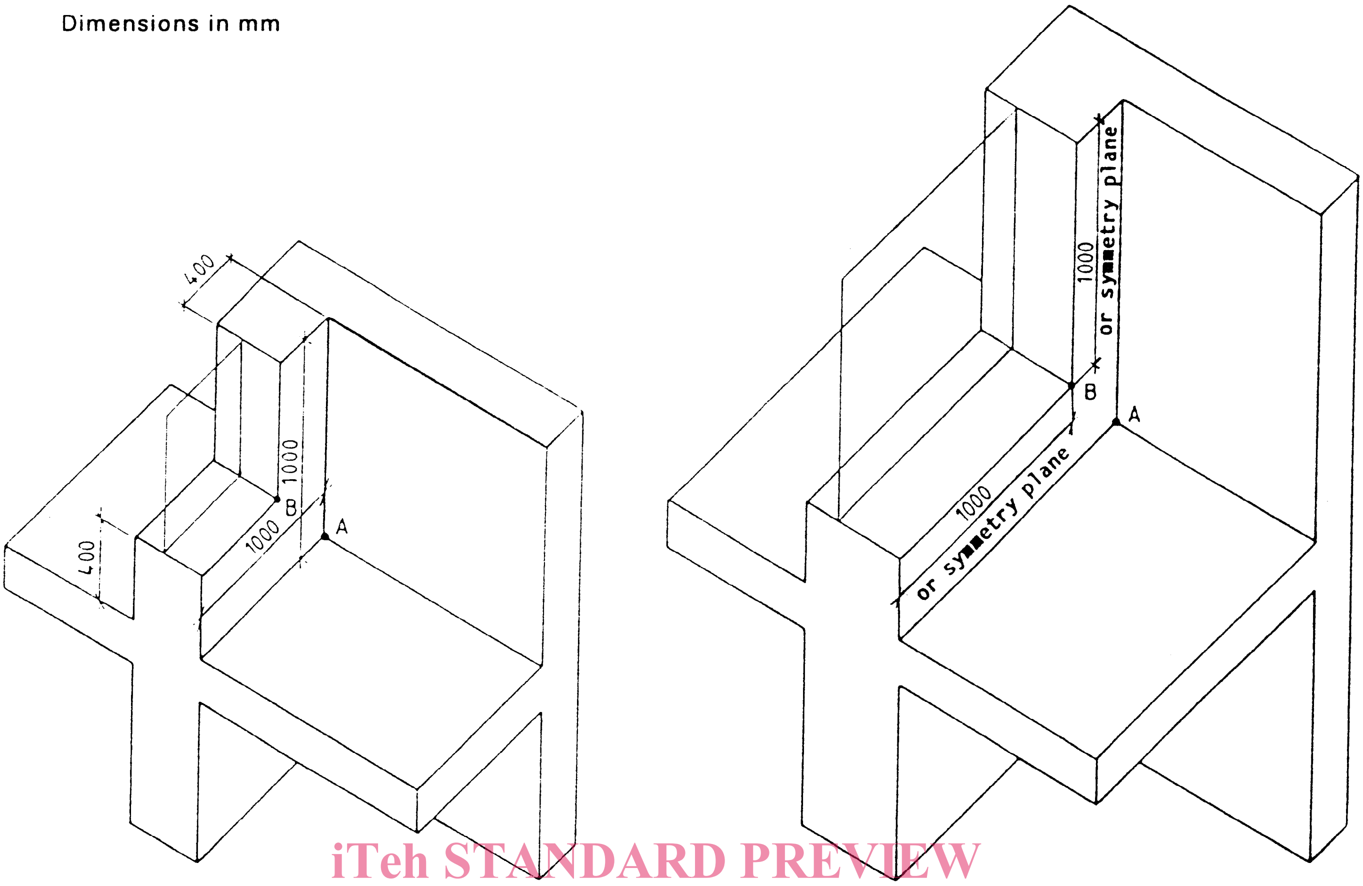


Figure 6: Two thermal bridges A and B in the same model.The thermal bridge nearest to the cut-off planes does not fulfil the condition of being at least 1 m from a cut-off plane (left). This difficulty is avoided by extending the model in two directions (right)

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

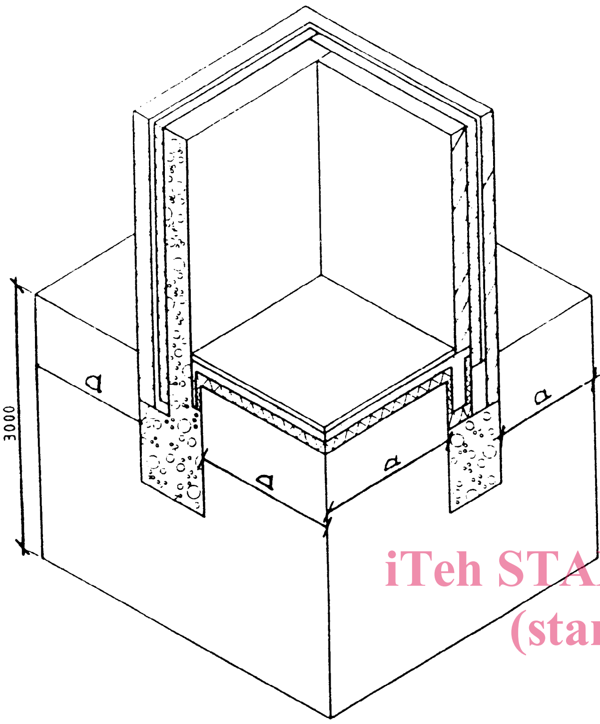
Distance to central element in metres

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.

Dimensions in mm



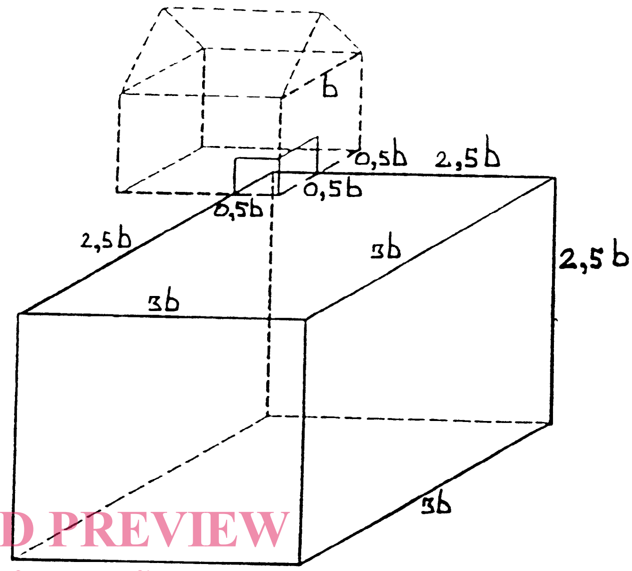


Figure 7a: Soil dimensions - calculation of surface temperatures

Figure 7b: Soil dimensions - calculation of heat flow

5.1.2 Adjustments to dimensions

Adjustments to the dimensions of the geometrical model with respect to the actual geometry are allowed if they have no significant influence on the result of the calculation; this can be assumed if the conditions in 5.2.1 are satisfied.

5.1.3 Auxiliary planes

The number of auxiliary planes in the model shall be such that adding more auxiliary planes does not change the temperature difference ratios ζ_{Rsi} by more than 0,005 (see also A.2).

NOTE: A guideline for fulfilling this requirement in many cases is (see figure 8a):
The distances between adjacent parallel planes should not exceed the following values:
- within the central element 25 mm
- within the flanking elements, measured from the construction plane which separates the central element from the flanking element:
25, 25, 50, 50, 50, 100, 200, 500, 1000, 2000 and 4000 mm.

For constructions with indentations of small dimensions (e.g. window profiles) a finer subdivision will be needed (see figure 8b).

Dimensions in mm

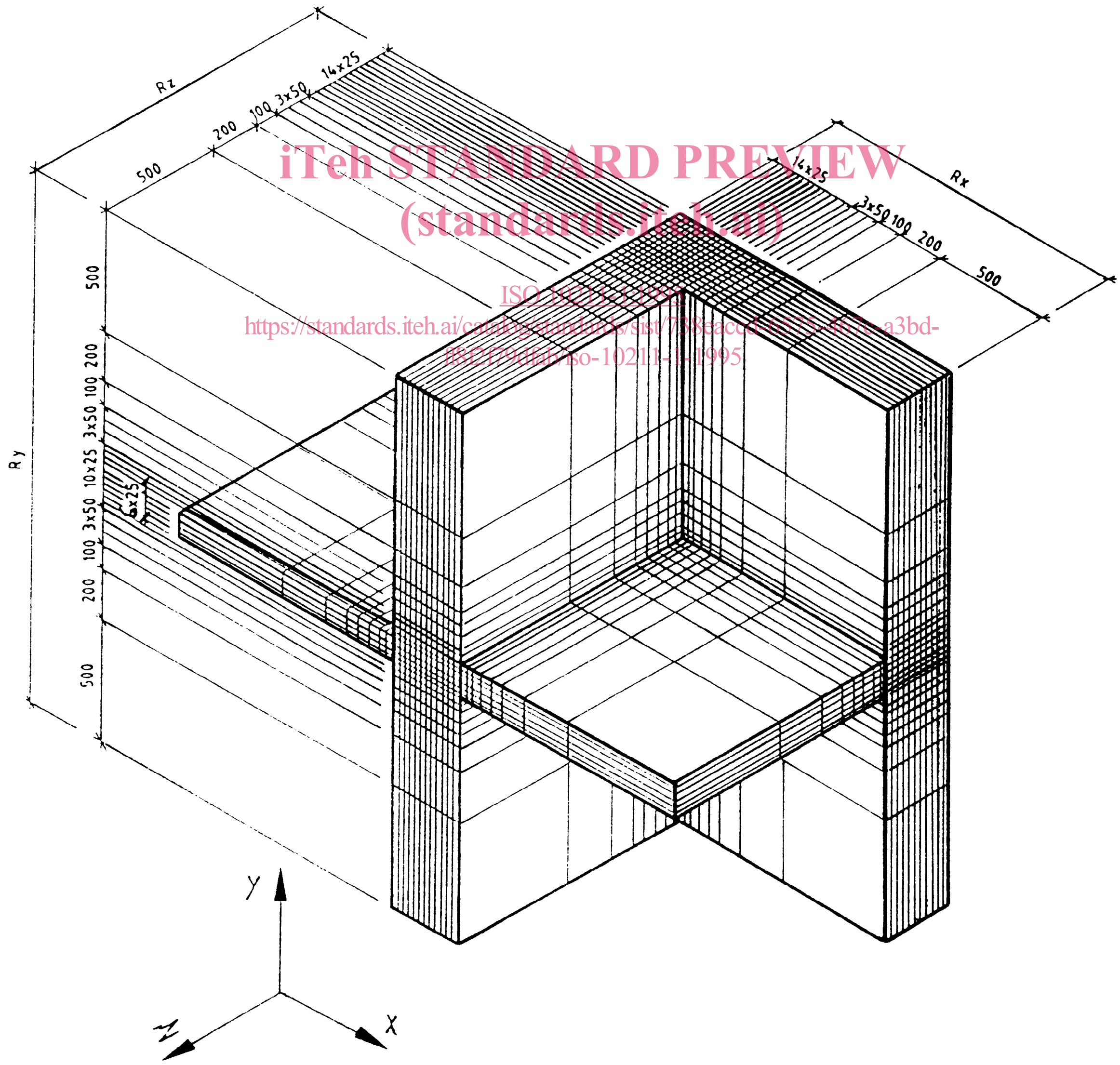


Figure 8a: Example of construction planes supplemented with auxiliary planes