INTERNATIONAL STANDARD

ISO 14683

Second edition
2007-12-01

Thermal bridges in building construction — Linear thermal transmittance — Simplified methods and default values

Ponts thermiques dans les bâtiments — Coefficient linéique de transmission thermique — Méthodes simplifiées et valeurs par défaut

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ISO copyright office
Case postale 56 • CH-1211 Geneva 20
Tel. + 41 22 749 01 11
Fax + 41 22 749 09 47
E-mail copyright@iso.org
Web www.iso.org

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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.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. 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.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 14683 was prepared by Technical Committee ISO/TC 163, *Thermal performance and energy use in the built environment*, Subcommittee SC 2, *Calculation methods*.

This second edition cancels and replaces the first edition (ISO 14683:1999), which has been technically revised.

The following principal changes have been made to the first edition:

— the Scope has been amended to remove the restriction on window and door frames and curtain walling, and specifies that the default values of linear thermal transmittance are provided for information;

— 5.2 is a new subclause replacing some elements previously contained in 4.2;

— 5.5 is a summary into a short text of the former 5.4, the remainder of which has been transferred into informative Annex A;

— Annex A contains values of linear thermal transmittance which have all been reviewed, many of them amended upwards as a result of changing the basis in Table A.1 (intermediate floor slabs thickness of 200 mm instead of 150 mm; frames in openings of thickness 60 mm instead of 100 mm).

Introduction

This International Standard provides the means (in part) to assess the contribution that building products and services make to energy conservation and to the overall energy performance of buildings.

Thermal bridges in building constructions give rise to changes in heat flow rates and surface temperatures compared with those of the unbridged structure. These heat flow rates and temperatures can be precisely determined by numerical calculation in accordance with ISO 10211. However, for linear thermal bridges, it is often convenient to use simplified methods or tabulated values to obtain an estimate of their linear thermal transmittance.

The effect of repeating thermal bridges which are part of an otherwise uniform building element, such as wall ties penetrating a thermal insulation layer or mortar joints in lightweight blockwork, needs to be included in the calculation of the thermal transmittance of the building element concerned, in accordance with ISO 6946.

Although not covered by this International Standard, it is worth noting that thermal bridges can also give rise to low internal surface temperatures, with an associated risk of surface condensation or mould growth.

Thermal bridges in building construction — Linear thermal transmittance — Simplified methods and default values

1 Scope

This International Standard deals with simplified methods for determining heat flows through linear thermal bridges which occur at junctions of building elements.

This International Standard specifies requirements relating to thermal bridge catalogues and manual calculation methods.

Default values of linear thermal transmittance are given in Annex A for information.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

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

ISO 10211, *Thermal bridges in building construction — Heat flows and surface temperatures — Detailed calculations*

3 Terms, definitions, symbols and units

3.1 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 7345 and the following apply.

3.1.1
linear thermal bridge
thermal bridge with a uniform cross section along one of the three orthogonal axes

3.1.2
point thermal bridge
localized thermal bridge whose influence can be represented by a point thermal transmittance

3.1.3
linear thermal transmittance
heat flow rate in the steady state divided by length and by the temperature difference between the environments on either side of a thermal bridge

NOTE The linear thermal transmittance is a quantity describing the influence of a linear thermal bridge on the total heat flow.

3.1.4
point thermal transmittance
heat flow rate in the steady state divided by the temperature difference between the environments on either side of a thermal bridge

NOTE The point thermal transmittance is a quantity describing the influence of a point thermal bridge on the total heat flow.

3.1.5
transmission heat transfer coefficient
heat flow rate due to thermal transmission through the fabric of a building, divided by the difference between the environment temperatures on either side of the construction

3.2 Symbols and units

Symbol	Quantity	Unit
A	area	m^2
b	width	m
d	thickness	m
H_{T}	transmission heat transfer coefficient	W/K
H_{D}	direct transmission heat transfer coefficient	W/K
H_{U}	transmission heat transfer coefficient through unconditioned spaces	W/K
l	length	m
R	thermal resistance	m^2·K/W
R_{se}	external surface resistance	m^2·K/W
R_{si}	internal surface resistance	m^2·K/W
U	thermal transmittance	W/(m^2·K)
θ	Celsius temperature	°C
λ	design thermal conductivity	W/(m·K)
Φ	heat flow rate	W
Ψ	linear thermal transmittance	W/(m·K)
χ	point thermal transmittance	W/K

3.3 Subscripts

Subscript	Definition
e	external
i	internal
oi	overall internal

4 Influence of thermal bridges on overall heat transfer

4.1 Transmission heat transfer coefficient

Between internal and external environments with temperatures θ_i and θ_e respectively, the transmission heat flow rate through the building envelope, Φ, is calculated using Equation (1):

$$\Phi = H_T \left(\theta_i - \theta_e\right) \quad (1)$$

The transmission heat transfer coefficient, H_T, is calculated using Equation (2):

$$H_T = H_D + H_g + H_U \quad (2)$$

where

H_D is the direct heat transfer coefficient through the building envelope defined by Equation (3);

H_g is the ground heat transfer coefficient calculated in accordance with ISO 13370;

H_U is the heat transfer coefficient through unconditioned spaces calculated in accordance with ISO 13789.

4.2 Linear thermal transmittance

The calculation of the transmission heat transfer coefficient includes the contribution due to thermal bridges, according to Equation (3):

$$H_D = \sum_i A_i U_i + \sum_k l_k \Psi_k + \sum_j \chi_j \quad (3)$$

where

A_i is the area of element i of the building envelope, in m²;

U_i is the thermal transmittance of element i of the building envelope, in W/(m²·K);

l_k is the length of linear thermal bridge k, in m;

Ψ_k is the linear thermal transmittance of linear thermal bridge k, in W/(m·K);

χ_j is the point thermal transmittance of the point thermal bridge j, in W/K.

In general, the influence of point thermal bridges (insofar as they result from the intersection of linear thermal bridges) can be neglected and so the correction term involving point thermal bridges can be omitted from Equation (3). If, however, there are significant point thermal bridges, then the point thermal transmittances should be calculated in accordance with ISO 10211.

Linear thermal bridges are generally liable to occur at the following locations in a building envelope:

— at junctions between external elements (corners of walls, wall to roof, wall to floor);

— at junctions of internal walls with external walls and roofs;

— at junctions of intermediate floors with external walls;

— at columns in external walls;

— around windows and doors.

4.3 Internal and external dimensions

There are three dimension systems commonly in use:

— internal dimensions, measured between the finished internal faces of each room in a building (thus excluding the thickness of internal partitions);

— overall internal dimensions, measured between the finished internal faces of the external elements of the building (thus including the thickness of internal partitions);

— external dimensions, measured between the finished external faces of the external elements of the building.

These are described further in ISO 13789.

Any of these dimension systems may be used, provided that the system chosen is used consistently for all parts of the building construction. Linear thermal transmittance values depend on the system used, i.e. on the areas used for one-dimensional heat flow in $\sum_i A_i U_i$ in Equation (3), but the total transmission coefficient H_T is the same provided that all thermal bridges are taken into account.

5 Determination of linear thermal transmittance

5.1 Available methods and expected accuracy

When selecting a particular method, its accuracy should reflect the accuracy required in calculating the overall heat transfer, taking into account the lengths of the linear thermal bridges. Possible methods for determining Ψ include numerical calculations (typical accuracy ± 5 %), thermal bridge catalogues (typical accuracy ± 20 %), manual calculations (typical accuracy ± 20 %), and default values (typical accuracy 0 % to 50 %). The methods are discussed further in 5.2 to 5.5.

Where the details are not yet designed, but the size and main form of the building is defined, such that the areas of the different elements of the building envelope such as roofs, walls and floors are known, only a rough estimate of the contributions of thermal bridges to the overall heat loss can be made.

When sufficient information is available, more accurate values of Ψ for each of the linear thermal bridges can be obtained by comparing the particular detail with the best fitting example from a thermal bridge catalogue and using that value of Ψ. Manual calculation methods can also be used at this stage.

When full details are known, all the methods to determine Ψ may be used, including numerical calculations which give the most precise value for Ψ.

5.2 Numerical calculations

The linear thermal transmittance, Ψ, shall be calculated in accordance with ISO 10211.

Any calculation of linear thermal transmittance, Ψ, shall state the system of dimensions on which it is based.

5.3 Thermal bridge catalogues

Examples of building details in thermal bridge catalogues have essentially fixed parameters (e.g. fixed dimensions and materials) and so are less flexible than calculations. In general, the examples given in a catalogue do not exactly match the actual detail being considered, and so applying the value of Ψ specified in the catalogue to an actual detail introduces an uncertainty. Nevertheless, the value of Ψ from the catalogue may be used, provided that both dimensions and thermal properties of the catalogue example are either similar to those of the detail being considered or are such that they are thermally less favourable than that of the detail being considered.

The numerical calculations on which the linear thermal transmittance values given in the catalogue are based shall be carried out in accordance with ISO 10211. The catalogue shall also provide the following information:

a) clear guidance on how values of Ψ are to be derived from the values given in the catalogue;

b) dimensions of the detail and thermal transmittance values of thermally homogeneous parts of the detail;

c) the internal and external surface resistances used for the calculation of the values given in the catalogue.

NOTE 1 When thermal bridge details are not yet fully designed, printed catalogues provide useful examples for the designer. However, more flexible catalogues using database systems can be used, where the exact dimensions and materials can be varied: the accuracy is then comparable to that of a numerical calculation.

NOTE 2 Preferably, the catalogue provides information on how the linear thermal transmittance for a given detail is affected by changes in the thermal conductivities or dimensions of the building components that comprise the thermal bridge. This can be done by tabulating coefficients that relate the change in linear thermal transmittance to the change in thermal conductivity and/or dimension.

5.4 Manual calculation methods

A manual calculation method shall provide the following information:

a) types of constructional details which apply;

b) dimensional limits for which the method is valid;

c) limits to the thermal conductivity of materials applied;

d) values of surface resistance to be used;

e) an estimate of accuracy (e.g. the maximum error).

NOTE Various manual calculation methods exist which are intended for use in calculations performed on hand-held calculators or by simple computer software. However, a general indication of accuracy for these methods cannot be given because most manual calculation methods apply only to a specific type of thermal bridge (e.g. constructions with sheet metal). Thus, over the specified range of application, a particular manual calculation may be very accurate, but outside that range it may be very inaccurate.

5.5 Default values of linear thermal transmittance

Tables of default values of linear thermal transmittance may be prepared in accordance with the rules given in this International Standard. Such tables shall give clear indications of the applicability of the values they contain and shall be based on calculations that do not underestimate the effect of the thermal bridges.

Table A.2 provides default values, calculated for parameters representing worst-case situations. These values can be used in the absence of more specific data for the thermal bridges concerned. It is recommended that Table A.2 is extended or replaced, where appropriate, on a national basis, in order to cover constructional details typically used.

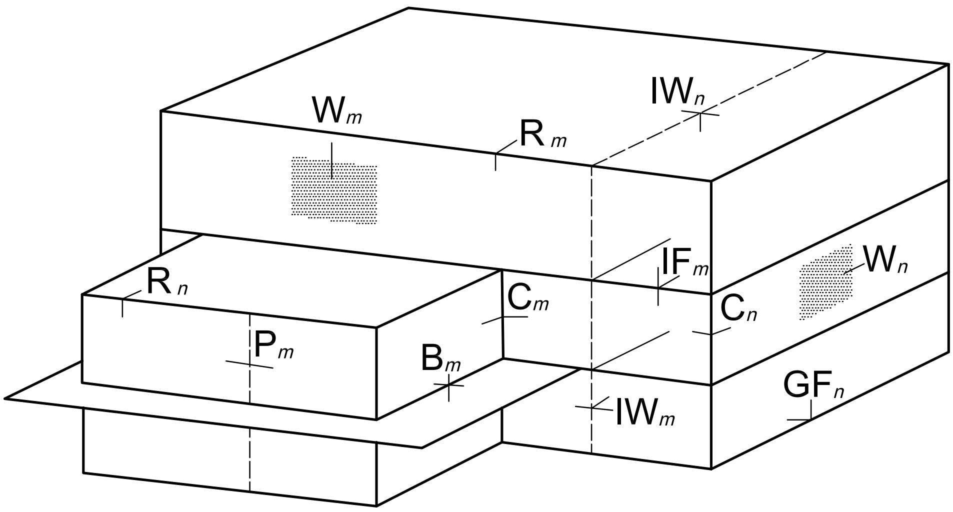
Annex A
(informative)

Default values of linear thermal transmittance

Table A.2 gives default values of Ψ for a range of commonly occurring types of two-dimensional thermal bridge, calculated using the data given in Table A.1. They are to be used when the actual value of Ψ is unknown, either when there are no details available for the particular thermal bridge, or where a rough value for Ψ is adequate for the accuracy required in the assessment of overall heat transfer. In Figure A.1, the notations R, B, C, GF, IF, IW, P and W refer to the location of the thermal bridge.

NOTE 1 These default values of Ψ are based on two-dimensional numerical modelling in accordance with ISO 10211. They generally represent the maximum effects of thermal bridging. Default values are valid only for consideration of heat transfer, and not for consideration of critical surface temperature to avoid surface condensation.

Figure A.1 shows typical locations of these common types of two-dimensional thermal bridge. The capital letters against each thermal bridge denote the type of thermal bridge and the suffix denotes the specific thermal bridge, e.g. IW_n denotes one thermal bridge at the junction of the external envelope with an internal wall and IW_m denotes another different thermal bridge of the same type. The potential thermal bridges in a specific building design can be identified by reference to Figure A.1 and the appropriate default value of linear thermal transmittance assigned to each using Table A.2.



Key

B_m, C_m, C_n, GF_n, IF_m, IW_m, IW_n, P_m, R_m, R_n, W_m, W_n locations of the thermal bridge

Figure A.1 — Sketch of a building showing the location and type of commonly-occurring thermal bridges according to the scheme given in Table A.2

Table A.2 shows details of thermal bridges grouped by type and with four locations of the principal insulating layer (i.e. the layer with the highest thermal resistance). The principal insulating layer can be located

a) at the outside of,

b) in the middle of,

c) at the inside of, or

d) all the way through

the non-bridged part of the particular building element. Case d) refers to where the building element is of lightweight masonry construction or is a timber frame wall.

For each thermal bridge type and location of the principal insulating layer, Table A.2 gives an outline sketch of each detail and values of Ψ, rounded to the nearest 0,05 W/(m·K), based on the three systems of measuring building dimensions listed in 4.3:

— Ψ_i based on internal dimensions;

— Ψ_{oi} based on overall internal dimensions;

— Ψ_e based on external dimensions.

In the case of external dimensions, the measurements are to the bottom of the floor slab, or to the bottom of the insulation (if below the floor slab).

NOTE 2 A worked example of the use of these default values of Ψ when calculating the transmission heat loss is given in Annex B.

The default values of Ψ in Table A.2 are based on two-dimensional numerical calculations using the parameters in Table A.1.

Table A.1 — Parameters used to calculate the data in Table A.2

For all details:		R_{si} = 0,13 m²·K/W R_{se} = 0,04 m²·K/W
For external walls: For internal walls:		d = 300 mm d = 200 mm
For walls with an insulation layer:	— thermal transmittance — thermal resistance of insulation layer	U = 0,343 W/(m²·K) R = 2,5 m² K/W
For lightweight walls:		U = 0,375 W/(m²·K)
For ground floors:	— floor slab — thermal conductivity of ground — thermal resistance of insulation layer	d = 200 mm λ = 2,0 W/(m·K) R = 2,5 m²·K/W
For intermediate floors:		d = 200 mm λ = 2,0 W/(m·K)
For roofs:	— thermal transmittance — thermal resistance of insulation layer	U = 0,365 W/(m²·K) R = 2,5 m²·K/W
For the frames in openings:		d = 60 mm
For columns:		d = 300 mm λ = 2,0 W/(m·K)

These parameters have been chosen so as to obtain default values of Ψ which are near to the maximum which is likely to occur in practice and are thus cautious overestimates of the thermal bridging effects, i.e. they will not underestimate the heat transfer through these thermal bridges.

Table A.2 — Default values of linear thermal transmittance

Dimensions in mm; linear thermal transmittance in W/(m·K)

Wall	Lightweight wall (including lightweight masonry and timber frame walls)	Insulating layer	Slab/pillar	Window frame

Roofs

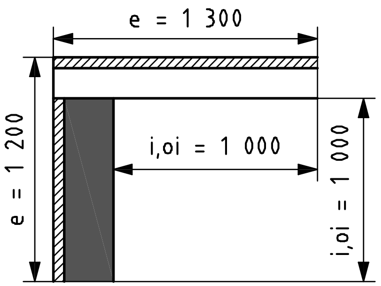
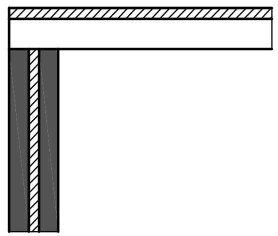
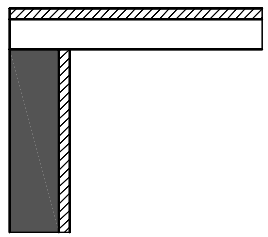
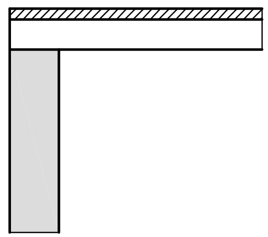
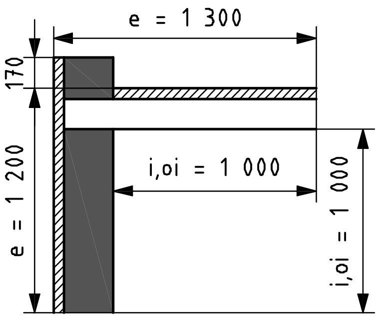
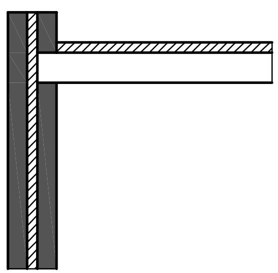
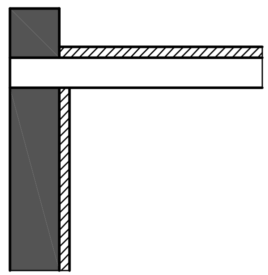
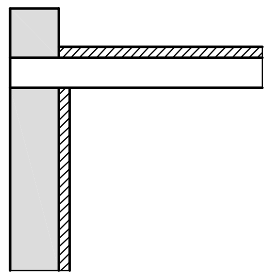
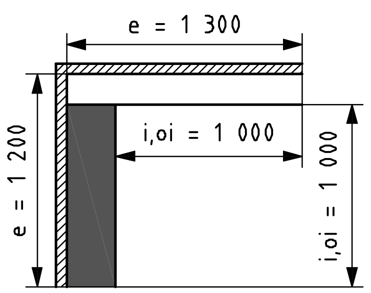
			
R1 Ψ_e = 0,55 Ψ_{oi} = 0,75 Ψ_i = 0,75	**R2** Ψ_e = 0,50 Ψ_{oi} = 0,75 Ψ_i = 0,75	**R3** Ψ_e = 0,40 Ψ_{oi} = 0,75 Ψ_i = 0,75	**R4** Ψ_e = 0,40 Ψ_{oi} = 0,65 Ψ_i = 0,65
			
R5 Ψ_e = 0,60 Ψ_{oi} = 0,80 Ψ_i = 0,80	**R6** Ψ_e = 0,50 Ψ_{oi} = 0,70 Ψ_i = 0,70	**R7** Ψ_e = 0,65 Ψ_{oi} = 0,85 Ψ_i = 0,85	**R8** Ψ_e = 0,45 Ψ_{oi} = 0,70 Ψ_i = 0,70

Table A.2 (*continued*)

Dimensions in mm; linear thermal transmittance in W/(m·K)

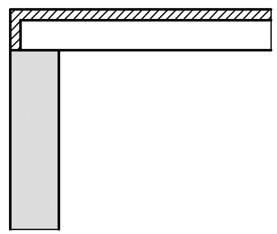
Wall	Lightweight wall (including lightweight masonry and timber frame walls)	Insulating layer	Slab/pillar	Window frame

Roofs (continued)



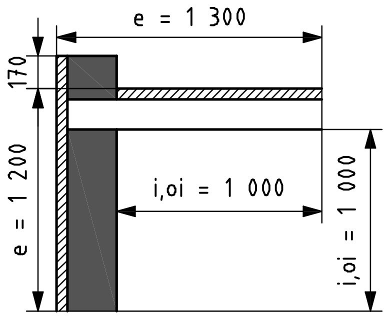
R9

Ψ_e = –0,05
Ψ_{oi} = 0,15
Ψ_i = 0,15



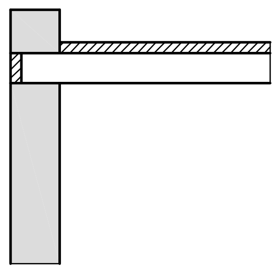
R10

Ψ_e = 0,00
Ψ_{oi} = 0,20
Ψ_i = 0,20



R11

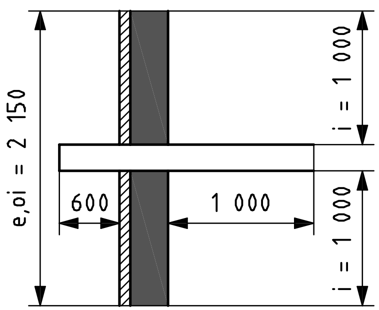
Ψ_e = 0,05
Ψ_{oi} = 0,25
Ψ_i = 0,25



R12

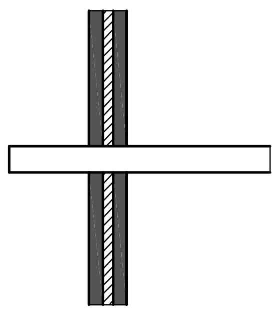
Ψ_e = 0,15
Ψ_{oi} = 0,40
Ψ_i = 0,40

Balconies



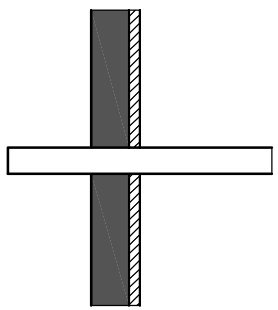
B1

Ψ_e = 0,95
Ψ_{oi} = 0,95
Ψ_i = 1,05



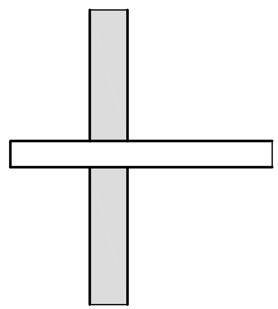
B2

Ψ_e = 0,95
Ψ_{oi} = 0,95
Ψ_i = 1,05



B3

Ψ_e = 0,90
Ψ_{oi} = 0,90
Ψ_i = 1,00



B4

Ψ_e = 0,70
Ψ_{oi} = 0,70
Ψ_i = 0,80

Table A.2 (*continued*)

Dimensions in mm; linear thermal transmittance in W/(m·K)

Wall	Lightweight wall (including lightweight masonry and timber frame walls)	Insulating layer	Slab/pillar	Window frame

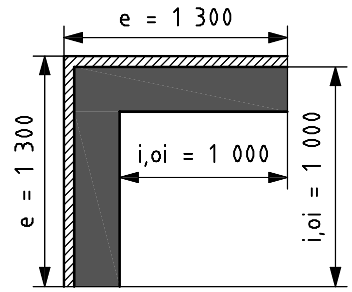
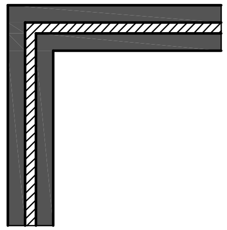
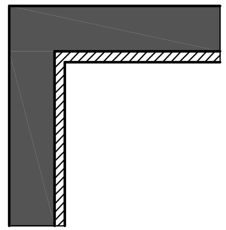
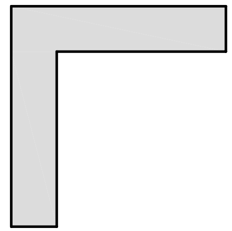
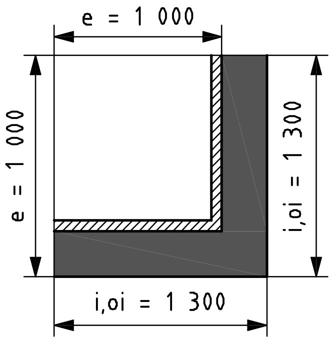
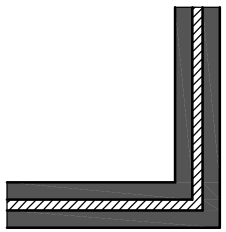
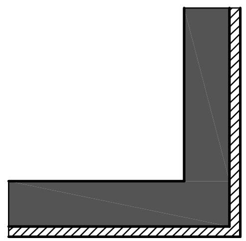
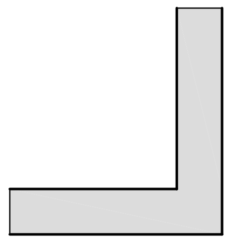
Corners			
			
C1 Ψ_e = –0,05 Ψ_{oi} = 0,15 Ψ_i = 0,15	**C2** Ψ_e = –0,10 Ψ_{oi} = 0,10 Ψ_i = 0,10	**C3** Ψ_e = –0,20 Ψ_{oi} = 0,05 Ψ_i = 0,05	**C4** Ψ_e = –0,15 Ψ_{oi} = 0,10 Ψ_i = 0,10
			
C5 Ψ_e = 0,05 Ψ_{oi} = –0,15 Ψ_i = –0,15	**C6** Ψ_e = 0,15 Ψ_{oi} = –0,10 Ψ_i = –0,10	**C7** Ψ_e = 0,15 Ψ_{oi} = –0,05 Ψ_i = –0,05	**C8** Ψ_e = 0,10 Ψ_{oi} = –0,10 Ψ_i = –0,10

Table A.2 (*continued*)

Dimensions in mm; linear thermal transmittance in W/(m·K)

Wall	Lightweight wall (including lightweight masonry and timber frame walls)	Insulating layer	Slab/pillar	Window frame

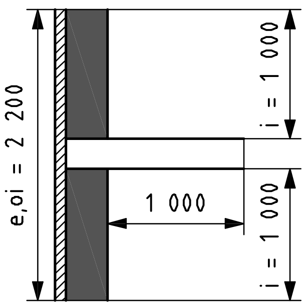
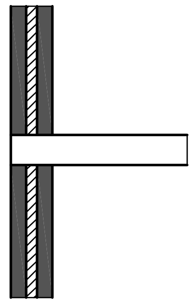
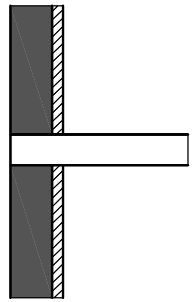
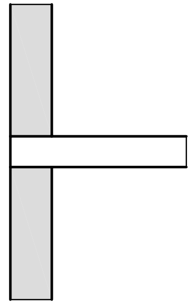
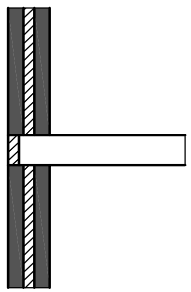
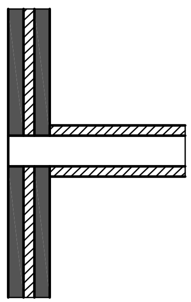
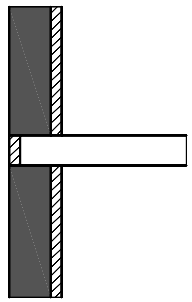
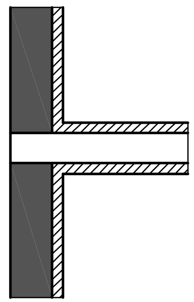
Intermediate floors			
			
IF1 Ψ_e = 0,00 Ψ_{oi} = 0,00 Ψ_i = 0,10	**IF2** Ψ_e = 0,95 Ψ_{oi} = 0,95 Ψ_i = 1,05	**IF3** Ψ_e = 0,90 Ψ_{oi} = 0,90 Ψ_i = 1,00	**IF4** Ψ_e = 0,70 Ψ_{oi} = 0,70 Ψ_i = 0,80
			
IF5 Ψ_e = 0,60 Ψ_{oi} = 0,60 Ψ_i = 0,65	**IF6** Ψ_e = 0,90 Ψ_{oi} = 0,90 Ψ_i = 1,00	**IF7** Ψ_e = 0,70 Ψ_{oi} = 0,70 Ψ_i = 0,80	**IF8** Ψ_e = 0,45 Ψ_{oi} = 0,45 Ψ_i = 0,60

Table A.2 (*continued*)

Dimensions in mm; linear thermal transmittance in W/(m·K)

Wall	Lightweight wall (including lightweight masonry and timber frame walls)	Insulating layer	Slab/pillar	Window frame

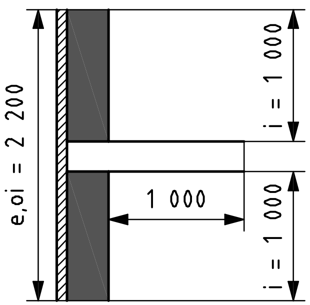
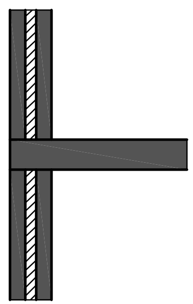
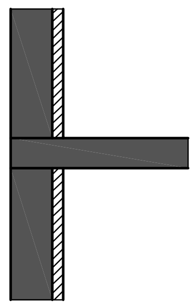
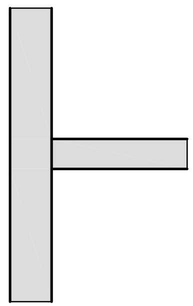
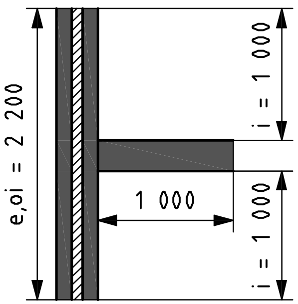
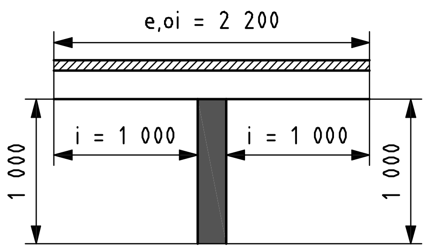
Internal walls			
 **IW1** Ψ_e = 0,00 Ψ_{oi} = 0,00 Ψ_i = 0,10	 **IW2** Ψ_e = 0,95 Ψ_{oi} = 0,95 Ψ_i = 1,05	 **IW3** Ψ_e = 0,90 Ψ_{oi} = 0,90 Ψ_i = 1,00	 **IW4** Ψ_e = 0,00 Ψ_{oi} = 0,00 Ψ_i = 0,20
 **IW5** Ψ_e = 0,00 Ψ_{oi} = 0,00 Ψ_i = 0,10	 **IW6** Ψ_e = 0,00 Ψ_{oi} = 0,00 Ψ_i = 0,10		

Table A.2 (*continued*)

Dimensions in mm; linear thermal transmittance in W/(m·K)

Wall	Lightweight wall (including lightweight masonry and timber frame walls)	Insulating layer	Slab/pillar	Window frame

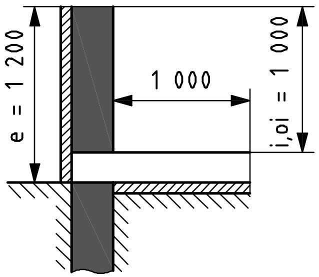
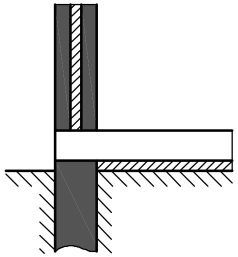
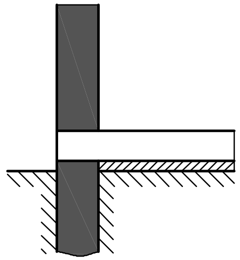
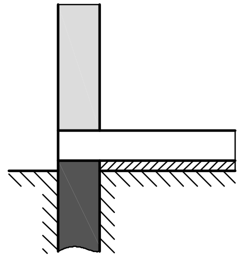
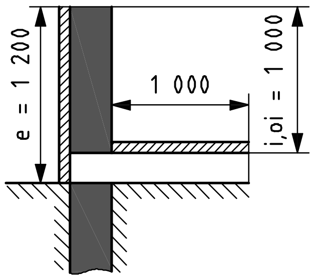
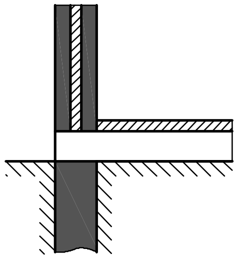
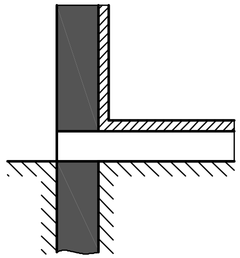
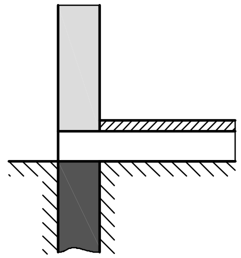
Slab-on-ground floors			
			
GF1 Ψ_e = 0,65 Ψ_{oi} = 0,80 Ψ_i = 0,80	**GF2** Ψ_e = 0,60 Ψ_{oi} = 0,75 Ψ_i = 0,75	**GF3** Ψ_e = 0,55 Ψ_{oi} = 0,70 Ψ_i = 0,70	**GF4** Ψ_e = 0,50 Ψ_{oi} = 0,65 Ψ_i = 0,65
			
GF5 Ψ_e = 0,60 Ψ_{oi} = 0,75 Ψ_i = 0,75	**GF6** Ψ_e = 0,45 Ψ_{oi} = 0,60 Ψ_i = 0,60	**GF7** Ψ_e = –0,05 Ψ_{oi} = 0,10 Ψ_i = 0,10	**GF8** Ψ_e = 0,05 Ψ_{oi} = 0,20 Ψ_i = 0,20

Table A.2 (*continued*)

Dimensions in mm; linear thermal transmittance in W/(m·K)

Wall	Lightweight wall (including lightweight masonry and timber frame walls)	Insulating layer	Slab/pillar	Window frame

Suspended ground floors

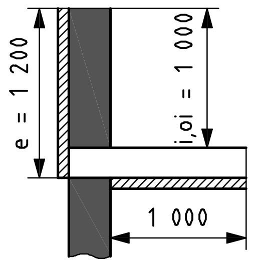
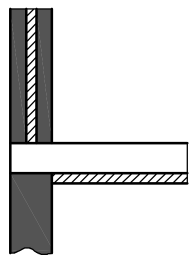
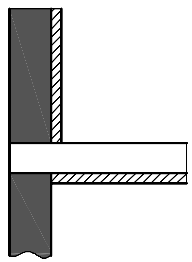
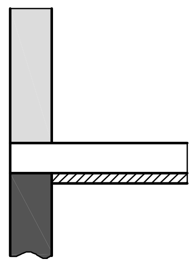
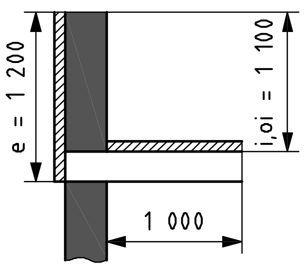
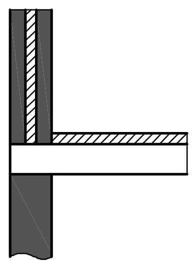
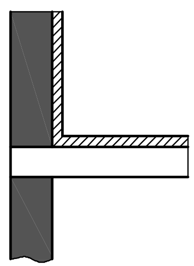
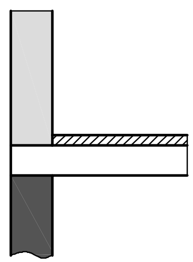
 **GF9** Ψ_e = 0,75 Ψ_{oi} = 0,95 Ψ_i = 0,95	 **GF10** Ψ_e = 0,65 Ψ_{oi} = 0,85 Ψ_i = 0,85	 **GF11** Ψ_e = 0,55 Ψ_{oi} = 0,75 Ψ_i = 0,75	 **GF12** Ψ_e = 0,50 Ψ_{oi} = 0,70 Ψ_i = 0,70
 **GF13** Ψ_e = 0,60 Ψ_{oi} = 0,80 Ψ_i = 0,80	 **GF14** Ψ_e = 0,45 Ψ_{oi} = 0,65 Ψ_i = 0,65	 **GF15** Ψ_e = –0,10 Ψ_{oi} = 0,10 Ψ_i = 0,10	 **GF16** Ψ_e = 0,00 Ψ_{oi} = 0,20 Ψ_i = 0,20

Table A.2 (*continued*)

Dimensions in mm; linear thermal transmittance in W/(m·K)

Wall	Lightweight wall (including lightweight masonry and timber frame walls)	Insulating layer	Slab/pillar	Window frame

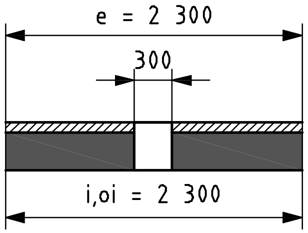
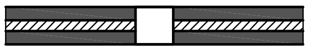
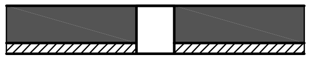
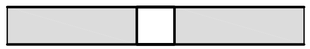
Pillars			
			
P1 Ψ_e = 1,30 Ψ_{oi} = 1,30 Ψ_i = 1,30	**P2** Ψ_e = 1,20 Ψ_{oi} = 1,20 Ψ_i = 1,20	**P3** Ψ_e = 1,15 Ψ_{oi} = 1,15 Ψ_i = 1,15	**P4** Ψ_e = 0,90 Ψ_{oi} = 0,90 Ψ_i = 0,90

Table A.2 (*continued*)

Dimensions in mm; linear thermal transmittance in W/(m·K)

Wall	Lightweight wall (including lightweight masonry and timber frame walls)	Insulating layer	Slab/pillar	Window frame

Window and door openings

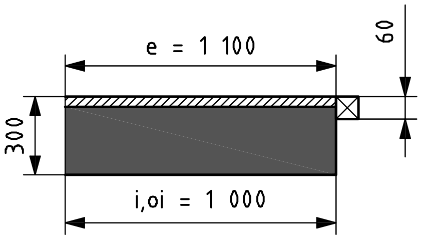
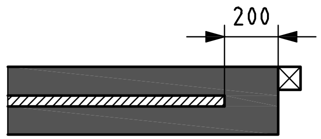
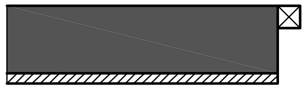
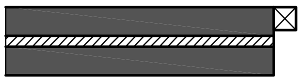
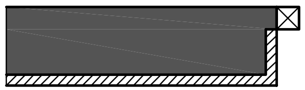
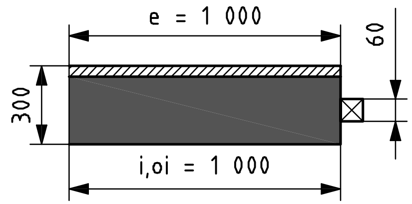
			
W1 Ψ_e = 0,00 Ψ_{oi} = 0,00 Ψ_i = 0,00	**W2** Ψ_e = 1,00 Ψ_{oi} = 1,00 Ψ_i = 1,00	**W3** Ψ_e = 0,80 Ψ_{oi} = 0,80 Ψ_i = 0,80	**W4** Ψ_e = 0,15 Ψ_{oi} = 0,15 Ψ_i = 0,15
			
W5 Ψ_e = 0,40 Ψ_{oi} = 0,40 Ψ_i = 0,40	**W6** Ψ_e = 0,10 Ψ_{oi} = 0,10 Ψ_i = 0,10		

Table A.2 (*continued*)

Dimensions in mm; linear thermal transmittance in W/(m·K)

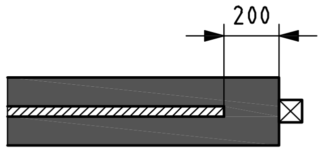
Wall	Lightweight wall (including lightweight masonry and timber frame walls)	Insulating layer	Slab/pillar	Window frame

Window and door openings (continued)



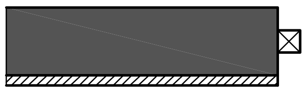
W7

Ψ_e = 0,45
Ψ_{oi} = 0,45
Ψ_i = 0,45



W8

Ψ_e = 1,00
Ψ_{oi} = 1,00
Ψ_i = 1,00

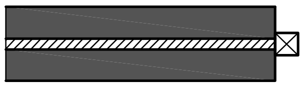


W9

Ψ_e = 0,60
Ψ_{oi} = 0,60
Ψ_i = 0,60

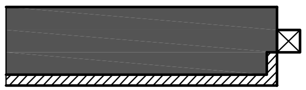
W10

Ψ_e = 0,10
Ψ_{oi} = 0,10
Ψ_i = 0,10



W11

Ψ_e = 0,00
Ψ_{oi} = 0,00
Ψ_i = 0,00



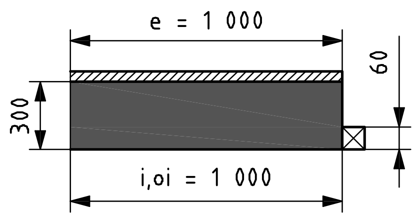
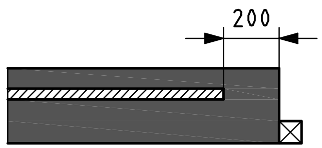
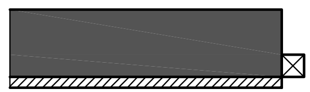
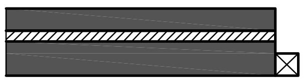
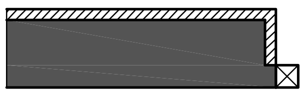
W12

Ψ_e = 0,10
Ψ_{oi} = 0,10
Ψ_i = 0,10

Table A.2 (*continued*)

Dimensions in mm; linear thermal transmittance in W/(m·K)

Legend				
Wall	Lightweight wall (including lightweight masonry and timber frame walls)	Insulating layer	Slab/pillar	Window frame

Window and door openings (continued)			
			
W13 Ψ_e = 0,80 Ψ_{oi} = 0,80 Ψ_i = 0,80	**W14** Ψ_e = 1,00 Ψ_{oi} = 1,00 Ψ_i = 1,00	**W15** Ψ_e = 0,00 Ψ_{oi} = 0,00 Ψ_i = 0,00	**W16** Ψ_e = 0,15 Ψ_{oi} = 0,15 Ψ_i = 0,15
			
W17 Ψ_e = 0,40 Ψ_{oi} = 0,40 Ψ_i = 0,40	**W18** Ψ_e = 0,20 Ψ_{oi} = 0,20 Ψ_i = 0,20		

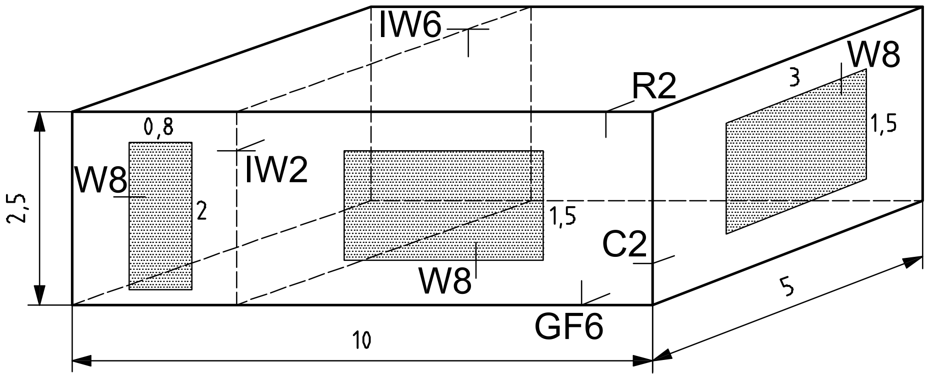
Annex B
(informative)

Example of the use of default values of linear thermal transmittance in calculating the heat transfer coefficient

B.1 Example building

Figure B.1 shows the schematic diagram of a single-storey building with a flat roof, solid ground floor, one partition wall, and two windows and a door in the external wall. The overall internal dimensions of the plane building elements are given in metres, and the location of the thermal bridge types are marked. IW2, R2, etc. refer to the types of thermal bridge, as illustrated in Table A.2.

Dimensions in metres



Key

C2, GF6, IW2, IW6, R2, W8 types of thermal bridge

Figure B.1 — Sketch of a building showing the overall internal dimensions and the location of the thermal bridges

The transmission heat transfer coefficient, H_D, (ignoring point thermal bridges) is given by:

$$H_D = \sum_i A_i U_i + \sum_k l_k \Psi_k \tag{B.1}$$

B.2 Using overall internal dimensions

The heat transfer coefficient through the various plane building elements is calculated in Table B.1. The value of U for each building element is multiplied by the overall internal area, A_{oi}, over which it applies, and the sum of these products gives the heat transfer coefficient through these building elements.

The value of the heat transfer coefficient through the two-dimensional thermal bridges is given in Table B.2. The value of Ψ_{oi} for each thermal bridge is multiplied by the length, l, over which it applies, and the sum of these products gives the heat transfer coefficient through these thermal bridges.

Table B.1 — Heat transfer coefficient through the plane building elements using overall internal dimensions

Building element	U W/(m[2]·K)	A_{oi} m[2]	$U A_{oi}$ W/K
Walls	0,40	64,4	25,76
Roof	0,30	50,0	15,00
Ground floor[a)]	0,35	50,0	17,50
Windows	3,50	9,0	31,50
Door	3,00	1,6	4,80
		Total	94,56

[a] The thermal transmittance of the floor is calculated in accordance with ISO 13370.

Table B.2 — Heat transfer coefficient through the two-dimensional thermal bridges using overall internal dimensions

Thermal bridge	Thermal bridge type[a]	Ψ_{oi} W/(m·K)	l_{oi} m	$\Psi_{oi}\, l_{oi}$ W/K
Wall/roof	R2	0,75	30,0	22,50
Wall/wall	C2	0,10	10,0	1,00
Wall/ground floor	GF6	0,60	30,0	18,00
Partition/wall	IW2	0,95	5,0	4,75
Partition/roof	IW6	0,00	5,0	0,00
Lintel, sill, reveal	W8	1,00	23,6	23,60
			Total	69,85

[a] From Table A.2.

From Tables B.1 and B.2:

$$H_{\mathrm{D}} = \sum_i A_i U_i + \sum_k l_k \Psi_k = 94{,}56 + 69{,}85 = 164{,}41\,\mathrm{W/K} \qquad \text{(B.2)}$$

Using overall internal dimensions, the heat transfer coefficient through the thermal bridges is 42 % of the total.

B.3 Using external dimensions

Assuming that the thickness of the wall is 0,3 m, that of the roof is 0,25 m and that of the floor is 0,25 m, and adding these thicknesses to the overall internal dimensions, gives external dimensions of the building of 10,6 m × 5,6 m × 3,0 m. The heat transfer coefficient through the various plane building elements using external dimensions is calculated in Table B.3. The value of U for each building element is multiplied by the external area, A_{e}, over which it applies, and the sum of these products gives the heat transfer coefficient through these building elements.

The calculated value of the heat transfer coefficient through the two-dimensional thermal bridges using external dimensions is given in Table B.4. The value of Ψ_{e} for each thermal bridge is multiplied by the length, l_{e}, over which it applies, and the sum of these products gives the heat transfer coefficient through these thermal bridges.

Table B.3 — Heat transfer coefficient through the plane building elements using external dimensions

Building element	U W/(m²·K)	A_e m²	$U A_e$ W/K
Wall	0,40	86,6	34,64
Roof	0,30	59,36	17,81
Ground floor[a]	0,35	59,36	20,78
Window	3,50	9,0	31,50
Door	3,00	1,6	4,80
		Total	109,52

[a] The thermal transmittance of the floor is calculated in accordance with ISO 13370.

Table B.4 — Heat transfer coefficient through the two-dimensional thermal bridges using external dimensions

Thermal bridge	Thermal bridge type [a]	Ψ_e W/(m·K)	l_e m	$\Psi_e\, l_e$ W/K
Wall/roof	R2	0,50	32,4	16,20
Wall/wall	C2	−0,10	12,0	−1,20
Wall/ground floor	GF6	0,45	32,4	14,58
Partition/wall	IW2	0,95	6,0	5,70
Partition/roof	IW6	0,00	5,6	0,00
Lintel, sill, reveal	W8	1,00	23,6	23,60
			Total	58,88

[a] From Table A.2.

From Tables B.3 and B.4:

$$H_D = \sum_i A_i U_i + \sum_k l_k \Psi_k = 109{,}52 + 58{,}88 = 168{,}40 \text{ W/K} \tag{B.3}$$

Using external dimensions, the heat transfer coefficient through the thermal bridges is 36 % of the total.

B.4 Using overall internal dimensions as in B.2, but with two of the thermal bridge details improved

Table B.5 shows the effect of improving some of the thermal bridges in the example (i.e. so that they have smaller values of Ψ). The thermal bridge type IW2 is replaced by IW5, and the type W8 by W11.

Table B.5 — Heat transfer coefficient through the two-dimensional thermal bridges using overall internal dimensions, with bridge types IW2 and W8 replaced by IW5 and W11 respectively

Thermal bridge	Thermal bridge type[a]	Ψ_{oi} W/(m·K)	l_{oi} m	$\Psi_{oi}\, l_{oi}$ W/K
Wall/roof	R2	0,75	30,0	22,50
Wall/wall	C2	0,10	10,0	1,00
Wall/ground floor	GF6	0,60	30,0	18,00
Partition/wall	IW5	0,00	5,0	0,00
Partition/roof	IW6	0,00	5,0	0,00
Lintel, Sill, Reveal	W11	0,00	23,6	0,00
			Total	41,50

[a] From Table A.2.

From Tables B.1 and B.5:

$$H_{\mathrm{D}} = \sum_i A_i U_i + \sum_k l_k \Psi_k = 94{,}56 + 41{,}50 = 136{,}06 \text{ W/K} \qquad \text{(B.4)}$$

Improving these two thermal bridge details has reduced the heat transfer coefficient through the thermal bridges by 41 %, from 69,85 W/K to 41,50 W/K, and has reduced the total heat transfer coefficient by 17 %, from 164,41 W/K to 136,06 W/K.

Bibliography

[1] ISO 6946, *Building components and building elements — Thermal resistance and thermal transmittance — Calculation method*

[2] ISO 13370, *Thermal performance of buildings — Heat transfer via the ground — Calculation methods*

[3] ISO 13789, *Thermal performance of buildings — Transmission and ventilation heat transfer coefficients — Calculation method*

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