INTERNATIONAL STANDARD

**ISO 10211**

Second edition
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# Thermal bridges in building construction — Heat flows and surface temperatures — Detailed calculations

*Ponts thermiques dans les bâtiments — Flux thermiques et températures superficielles — Calculs détaillés*



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ISO copyright office
Ch. de Blandonnet 8 • CP 401
CH-1214 Vernier, Geneva, Switzerland
Tel. +41 22 749 01 11
Fax +41 22 749 09 47
copyright@iso.org
www.iso.org

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# Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www. iso. org/directives).

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. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www. iso. org/patents).

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ISO 10211 was prepared by ISO Technical Committee ISO/TC 163, *Thermal performance and energy use in the built environment*, Subcommittee SC 2, *Calculation methods*, in collaboration with the European Committee for Standardization (CEN) Technical Committee CEN/TC 89, *Thermal performance of buildings and building components*, in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement).



This second edition cancels and replaces the first edition (ISO 10211:2007), which has been technically revised.

The changes in the second edition are mostly editorial. The standard has been re-drafted according to CEN/TS 16629:2014.

# Introduction

This document is part of a series aimed at the international harmonization of the methodology for assessing the energy performance of buildings. Throughout, this series is referred to as a “set of EPB standards”.

All EPB standards follow specific rules to ensure overall consistency, unambiguity and transparency.

All EPB standards provide a certain flexibility with regard to the methods, the required input data and references to other EPB standards, by the introduction of a normative template in Annex A and Annex B with informative default choices.

For the correct use of this document, a normative template is given in Annex A to specify these choices. Informative default choices are provided in Annex B.

The main target groups for this document are architects, engineers and regulators.

Use by or for regulators: In case the document is used in the context of national or regional legal requirements, mandatory choices may be given at national or regional level for such specific applications. These choices (either the informative default choices from Annex B or choices adapted to national/regional needs, but in any case following the template of Annex A) can be made available as national annex or as separate (e.g. legal) document (national data sheet).

NOTE 1 So in this case:

— the regulators will specify the choices;

— the individual user will apply the document to assess the energy performance of a building, and thereby use the choices made by the regulators.



Topics addressed in this document can be subject to public regulation. Public regulation on the same topics can override the default values in Annex B. Public regulation on the same topics can even, for certain applications, override the use of this document. Legal requirements and choices are in general not published in standards but in legal documents. In order to avoid double publications and difficult updating of double documents, a national annex may refer to the legal texts where national choices have been made by public authorities. Different national annexes or national data sheets are possible, for different applications.



It is expected, if the default values, choices and references to other EPB standards in Annex B are not followed due to national regulations, policy or traditions, that:

— national or regional authorities prepare data sheets containing the choices and national or regional values, according to the model in Annex A. In this case a national annex (e.g. NA) is recommended, containing a reference to these data sheets;

— or, by default, the national standards body will consider the possibility to add or include a national annex in agreement with the template of Annex A, in accordance to the legal documents that give national or regional values and choices.

Further target groups are parties wanting to motivate their assumptions by classifying the building energy performance for a dedicated building stock.

More information is provided in the Technical Report accompanying this document (ISO/TR 52019-2).

The subset of EPB standards prepared under the responsibility of ISO/TC 163/SC 2 cover *inter alia*:

— calculation procedures on the overall energy use and energy performance of buildings;

— calculation procedures on the internal temperature in buildings (e.g. in case of no space heating or cooling);

— indicators for partial EPB requirements related to thermal energy balance and fabric features;

— calculation methods covering the performance and thermal, hygrothermal, solar and visual characteristics of specific parts of the building and specific building elements and components, such as opaque envelope elements, ground floor, windows and facades.

ISO/TC 163/SC 2 cooperates with other technical committees for the details on appliances, technical building systems, indoor environment, etc.

This document sets out the specifications for a geometrical model of a thermal bridge for the numerical calculation of linear thermal transmittances, point thermal transmittances and internal surface temperatures.

Table 1 shows the relative position of this document within the set of EPB standards in the context of the modular structure as set out in ISO 52000-1.

NOTE 2 In ISO/TR 52000-2 the same table can be found, with, for each module, the numbers of the relevant EPB standards and accompanying technical reports that are published or in preparation.

NOTE 3 The modules represent EPB standards, although one EPB standard could cover more than one module and one module could be covered by more than one EPB standard, for instance, a simplified and a detailed method respectively. See also Tables A.1 and B.1.

**Table 1 — Position of this document (*in casu* M2–5) within the modular structure of the set of EPB standards**

| | Overarching | | Building (as such) | | Technical Building Systems | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sub-module | Descriptions | | Descrip-tions | | Descriptions | Heat-ing | Cool-ing | Ven-tila-tion | Humidi-fication | Dehu-midifi-cation | Domestic hot water | Lighting | Building automa-tion and control | PV, wind, .. |
| sub1 | | M1 | | M2 | M3 | M4 | M5 | M6 | M7 | M8 | M9 | M10 | M11 | |
| 1 | General | | General | | General | | | | | | | | | |
| 2 | Common terms and definitions; symbols, units and subscripts | | Building energy needs | | Needs | | | | | | | | [a] | |
| 3 | Applications | | (Free) indoor conditions without systems | | Maximum load and power | | | | | | | | | |
| 4 | Ways to express energy performance | | Ways to express energy performance | | Ways to express energy performance | | | | | | | | | |
| 5 | Building categories and building boundaries | | Heat transfer by transmission | ISO 10211 | Emission and control | | | | | | | | | |

[a] The shaded modules are not applicable.

**Table 1** *(continued)*

| | Overarching | | Building (as such) | | Technical Building Systems | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Sub-module** | **Descriptions** | | **Descriptions** | | **Descriptions** | **Heating** | **Cooling** | **Ventilation** | **Humidification** | **Dehumidification** | **Domestic hot water** | **Lighting** | **Building automation and control** | **PV, wind, ..** |
| **sub1** | | **M1** | | **M2** | | **M3** | **M4** | **M5** | **M6** | **M7** | **M8** | **M9** | **M10** | **M11** |
| 6 | Building occupancy and operating conditions | | Heat transfer by infiltration and ventilation | | Distribution and control | | | | | | | | | |
| 7 | Aggregation of energy services and energy carriers | | Internal heat gains | | Storage and control | | | | | | | | | |
| 8 | Building zoning | | Solar heat gains | | Generation and control | | | | | | | | | |
| 9 | Calculated energy performance | | Building dynamics (thermal mass) | | Load dispatching and operating conditions | | | | | | | | | |
| 10 | Measured energy performance | | Measured energy performance | | Measured Energy Performance | | | | | | | | | |
| 11 | Inspection | | Inspection | | Inspection | | | | | | | | | |
| 12 | Ways to express indoor comfort | | | | BMS | | | | | | | | | |
| 13 | External environment conditions | | | | | | | | | | | | | |
| 14 | Economic calculation | | | | | | | | | | | | | |

[a] The shaded modules are not applicable.

# Thermal bridges in building construction — Heat flows and surface temperatures — Detailed calculations

## 1 Scope

This document sets out the specifications for a three-dimensional and a two-dimensional geometrical model of a thermal bridge for the numerical calculation of

— heat flows, in order to assess the overall heat loss from a building or part of it, and

— 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.

This document is based upon the following assumptions:

— all physical properties are independent of temperature;

— there are no heat sources within the building element.

This document can also be used for the derivation of linear and point thermal transmittances and of surface temperature factors.



NOTE Table 1 in the Introduction shows the relative position of this document within the set of EPB standards in the context of the modular structure as set out in ISO 52000-1.



## 2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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 6946, *Building components and building elements — Thermal resistance and thermal transmittance — Calculation method*

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

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

ISO 13788, *Hygrothermal performance of building components and building elements — Internal surface temperature to avoid critical surface humidity and interstitial condensation — Calculation methods*

ISO 10456, *Building materials and products — Hygrothermal properties — Tabulated design values and procedures for determining declared and design thermal values*

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

ISO 52000-1:2017, *Energy performance of buildings — Overarching EPB assessment — Part 1: General framework and procedures*

NOTE 1 Default references to EPB standards other than ISO 52000-1 are identified by the EPB module code number and given in Annex A (normative template in Table A.1) and Annex B (informative default choice in Table B.1).

EXAMPLE EPB module code number: M5–5, or M5–5,1 (if module M5–5 is subdivided), or M5–5/1 (if reference to a specific clause of the standard covering M5–5).

NOTE 2 In this document, there are no choices in references to other EPB standards. The sentence and note above is kept to maintain uniformity between all EPB standards.

## 3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 7345, ISO 52000-1, and the following apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— IEC Electropedia: available at http://www.electropedia.org/

— ISO Online browsing platform: available at http://www.iso.org/obp

**3.1**
**thermal bridge**
part of the building envelope where the otherwise uniform thermal resistance is significantly changed by full or partial penetration of the building envelope by materials with a different thermal conductivity, and/or a change in thickness of the fabric, and/or a difference between internal and external areas, such as occur at wall/floor/ceiling junctions

**3.2**
**linear thermal bridge**
*thermal bridge* (3.1) with a uniform cross-section along one of the three orthogonal axes



**3.3**
**point thermal bridge**
localized *thermal bridge* (3.1) whose influence can be represented by a *point thermal transmittance* (3.20)



**3.4**
**three-dimensional geometrical model**
**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

Note 1 to entry: See Figure 1.

**3.5**
**three-dimensional flanking element**
**3-D flanking element**
part of a *3-D geometrical model* (3.4) which, when considered in isolation, can be represented by a *2-D geometrical model* (3.7)

Note 1 to entry: See Figure 1 and Figure 2.

**3.6**
**three-dimensional central element**
**3-D central element**
part of a *3-D geometrical model* (3.4) which is not a *3-D flanking element* (3.5)

Note 1 to entry: See Figure 1.

Note 2 to entry: A central element is represented by a *3-D geometrical model* (3.4).

**3.7**
**two-dimensional geometrical model**
**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

Note 1 to entry: See Figure 2.

Note 2 to entry: A 2-D geometrical model is used for two-dimensional calculations.

**3.8**
**two-dimensional flanking element**
**2-D flanking element**
part of a *2-D geometrical model* (3.7) which, when considered in isolation, consists of plane, parallel material layers

Note 1 to entry: The plane, parallel material layers can be homogeneous or non-homogeneous.

**3.9**
**two-dimensional central element**
**2-D central element**
part of a *2-D geometrical model* (3.7) which is not a *2-D flanking element* (3.8)

**3.10**
**construction plane**
plane in the *3-D geometrical model* (3.4) or *2-D geometrical model* (3.7) which separates different materials, and/or the geometrical model from the remainder of the construction, and/or the flanking elements from the central element



Note 1 to entry: See Figure 3.



**3.11**
**cut-off plane**
*construction plane* (3.10) that is a boundary to the *3-D geometrical model* (3.4) or *2-D geometrical model* (3.7) by separating the model from the remainder of the construction

Note 1 to entry: See Figure 3.

**3.12**
**auxiliary plane**
plane which, in addition to the *construction planes* (3.10), divides the geometrical model into a number of cells

**3.13**
**quasi-homogeneous layer**
layer which consists of two or more materials with different thermal conductivities, but which can be considered as homogeneous with an equivalent thermal conductivity

Note 1 to entry: See Figure 4.

**3.14**
**temperature factor at the internal surface**
difference between internal surface temperature and external temperature, divided by the difference between internal temperature and external temperature, calculated with a surface resistance $R_{si}$ at the internal surface

**3.15**
**temperature weighting factor**
weighting factor which states the respective influence of the temperatures of the different thermal environments upon the surface temperature at the point under consideration

**3.16**
**external boundary temperature**
external air temperature, assuming that the air temperature and the radiant temperature seen by the surface are equal

**3.17**
**internal boundary temperature**
operative temperature, taken as the arithmetic mean value of internal air temperature and mean radiant temperature of all surfaces surrounding the internal environment

**3.18**
**thermal coupling coefficient**
heat flow rate per temperature difference between two environments which are thermally connected by the construction under consideration

**3.19**
**linear thermal transmittance**
heat flow rate in the steady-state compared to a reference heat flow rate calculated disregarding the *thermal bridge* (3.1), divided by length and by the temperature difference between the environments on either side of a *linear thermal bridge* (3.2)

Note 1 to entry: The linear thermal transmittance is a quantity describing the influence of a linear thermal bridge on the total heat flow.

**3.20**
**point thermal transmittance**
heat flow rate in the steady-state compared to a reference heat flow rate calculated disregarding the *thermal bridge* (3.1), divided by the temperature difference between the environments on either side of a *point thermal bridge* (3.3)

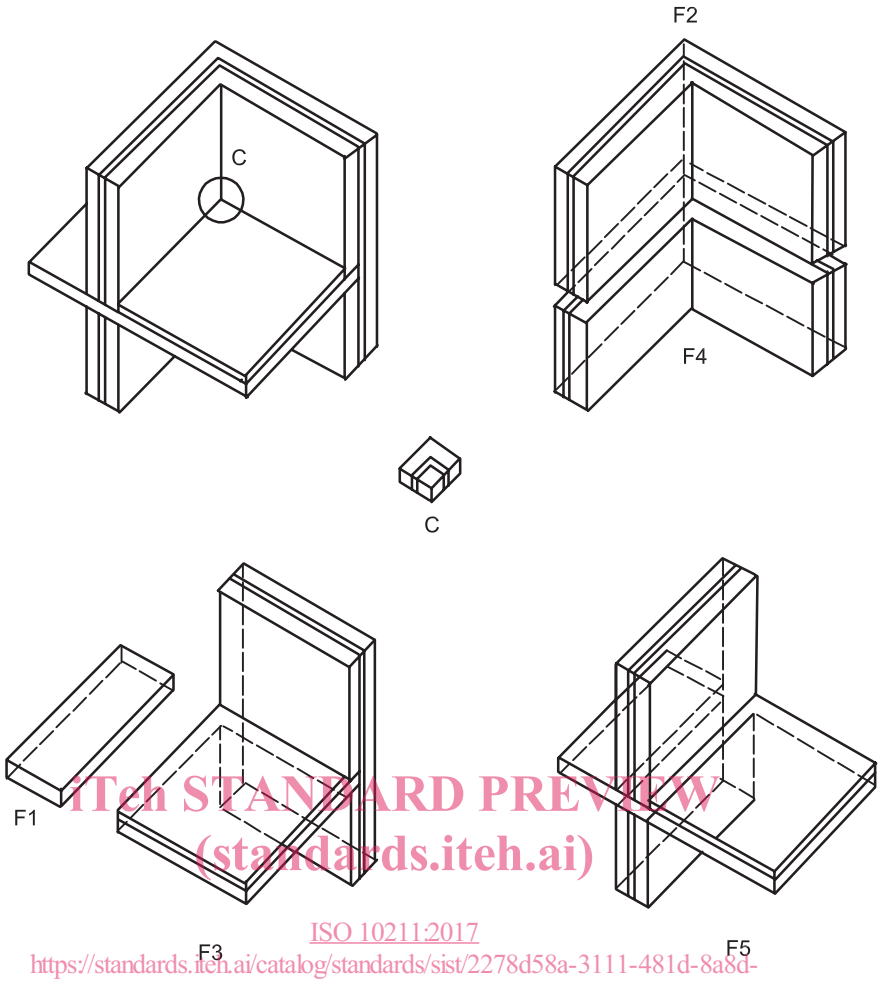
Note 1 to entry: The point thermal transmittance is a quantity describing the influence of a point thermal bridge on the total heat flow.



**3.21**
**EPB standard**
standard that complies with the requirements given in ISO 52000-1, CEN/TS 16628[5] and CEN/TS 16629[6]

Note 1 to entry: These three basic EPB documents were developed under a mandate given to CEN by the European Commission and the European Free Trade Association and support essential requirements of EU Directive 2010/31/EU on the energy performance of buildings. Several EPB standards and related documents are developed or revised under the same mandate.

[SOURCE: ISO 52000-1:2017, 3.5.14]





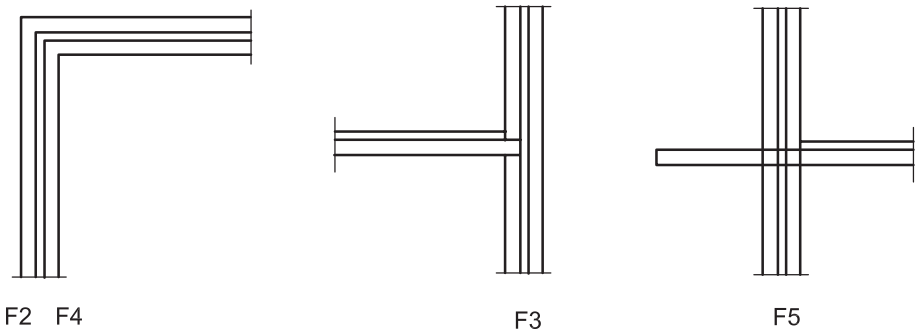

**Key**

F1, F2, F3, F4, F5 3-D flanking elements

C 3-D central element

NOTE 3-D Flanking elements have constant cross-sections perpendicular to at least one axis; the 3-D central element is the remaining part.

**Figure 1 — 3-D geometrical model with five 3-D flanking elements and one 3-D central element**

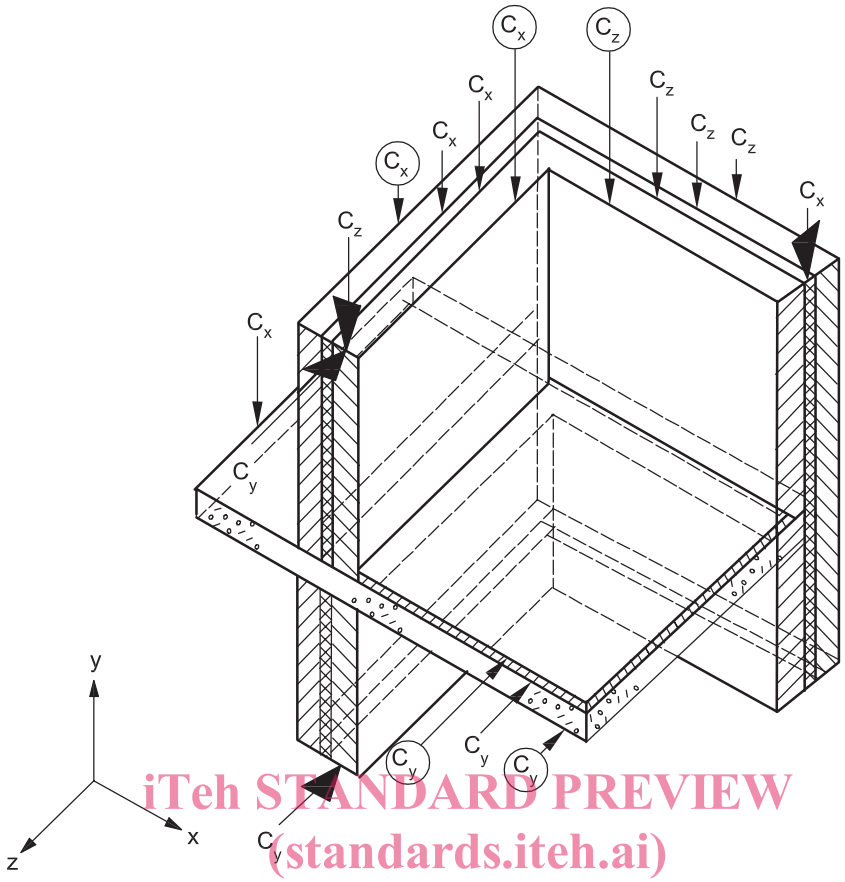



**Key**

F1, F2, F3, F4, F5 3-D flanking elements

NOTE F2 to F5 refer to Figure 1.

**Figure 2 — Cross-sections of the 3-D flanking elements in a 3-D geometrical model treated as 2-D geometrical models**






**Key**

$C_x$ construction planes perpendicular to the x-axis

$C_y$ construction planes perpendicular to the y-axis

$C_z$ construction planes perpendicular to the z-axis



NOTE Cut-off planes are indicated with enlarged arrows; planes that separate flanking elements from central element are encircled.

**Figure 3 — Example of a 3-D geometrical model showing construction planes**

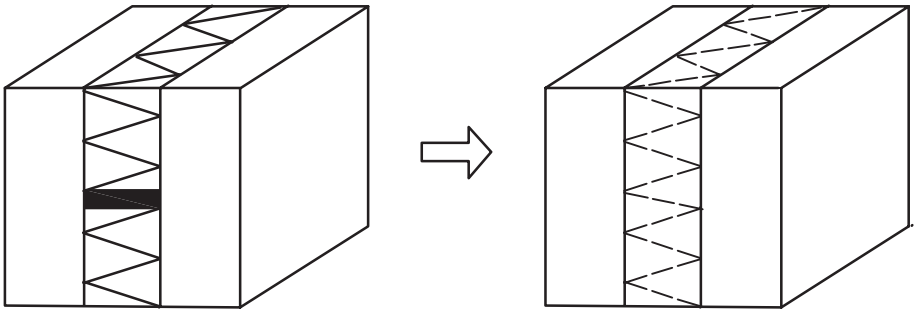


**Figure 4 — Example of a minor point thermal bridge giving rise to three-dimensional heat flow, incorporated into a quasi-homogeneous layer**

# 4 Symbols and subscripts

## 4.1 Symbols

For the purposes of this document, the symbols given in ISO 52000-1 and the following apply.

| Symbol | Quantity | Unit |
|---|---|---|
| $A$ | area | $m^2$ |
| $B$ | characteristic dimension of floor | m |
| $b$ | width | m |
| $d$ | thickness | m |
| $f$ | temperature factor at the internal surface | — |
| $g$ | temperature weighting factor | — |
| $h$ | height | m |
| $L$ | thermal coupling coefficient | W/(m·K) |
| $L_{2D}$ | thermal coupling coefficient from two-dimensional calculation | W/(m·K) |
| $L_{3D}$ | thermal coupling coefficient from three-dimensional calculation | W/K |
| $l$ | length | m |
| $N$ | number | — |
| $q$ | density of heat flow rate | $W/m^2$ |
| $R$ | thermal resistance | $m^2·K/W$ |
| $T$ | thermodynamic temperature | K |
| $t$ | time | month |
| $U$ | thermal transmittance | $W/(m^2·K)$ |
| $V$ | volume | $m^3$ |
| $w$ | wall thickness | m |
| $z$ | depth of floor surface below ground level | m |
| $\Phi$ | heat flow rate | W |
| $\lambda$ | thermal conductivity | W/(m·K) |
| $\theta$ | Celsius temperature | °C |
| $\Delta\theta$ | temperature difference | K |
| $\chi$ | point thermal transmittance | W/K |
| $\Psi$ | linear thermal transmittance | W/(m·K) |



## 4.2 Subscripts

For the purposes of this document, the subscripts given in ISO 52000-1 and the following apply.

| Subscript | Definition |
|---|---|
| b | basement, below ground level |
| c | component |
| e | external |
| f | floor |
| g | air layer, air gap (8.6) |
| g | ground (12.4) |
| ie | from internal to external |
| iu | from internal to unheated |
| int | internal |