INTERNATIONAL STANDARD

ISO 13370

Third edition
2017-06

Thermal performance of buildings — Heat transfer via the ground — Calculation methods

Performance thermique des bâtiments — Transfert de chaleur par le sol — Méthodes de calcul

Reference number
ISO 13370:2017(E)

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

Contents

Page

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.

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).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation on the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see the following URL: www.iso. org/iso/foreword.html.

ISO 13370 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 third edition cancels and replaces the second edition (ISO 13370:2007), which has been technically revised.

The changes in this third edition are mostly editorial. This document has been re-drafted according to CEN/TS 16629:2014. Some additional output variables have been introduced to facilitate the linkages between this document and ISO 52016-1.

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 (ISO/TR 52019-2) accompanying this document.

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 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.

In contrast with ISO 6946, which gives the method of calculation of the thermal transmittance of building elements in contact with the external air, this document deals with elements in thermal contact with the ground. The division between these two International Standards is at the level of the inside floor surface for slab-on-ground floors, suspended floors and unheated basements, and at the level of the external ground surface for heated basements. In general, a term to allow for a thermal bridge associated with the wall/floor junction is included when assessing the total heat loss from a building using methods such as ISO 13789.

The calculation of heat transfer through the ground can be done by numerical calculations, which also allow analysis of thermal bridges, including wall/floor junctions, for assessment of minimum internal surface temperatures.

In this document, methods are provided which take account of the three-dimensional nature of the heat flow in the ground below buildings.

Thermal transmittances of floors give useful comparative values of the insulation properties of different floor constructions and are used in building regulations in some countries for the limitation of heat losses through floors.

Thermal transmittance, although defined for steady-state conditions, also relates average heat flow to average temperature difference. In the case of walls and roofs exposed to the external air, there are daily periodic variations in heat flow into and out of storage related to daily temperature variations, but this averages out, and the daily average heat loss can be found from the thermal transmittance and daily average inside-to-outside temperature difference. For floors and basement walls in contact with the ground, however, the large thermal inertia of the ground results in periodic heat flows related to the annual cycle of internal and external temperatures. The steady-state heat flow is often a good approximation to the average heat flow over the heating season.

In addition to the steady-state part, a detailed assessment of floor losses is obtained from annual periodic heat transfer coefficients related to the thermal capacity of the soil, as well as its thermal conductivity, together with the amplitude of annual variations in monthly mean temperature.

Annex F provides a method for incorporating heat transfers to and from the ground into calculations undertaken at short time intervals (e.g. 1 h).

ISO/TR 52019-2 provides information on

— thermal properties of the ground,

— the influence of flowing ground water,

— ground floors with an embedded heating or cooling system, and

— ground floors of cold stores

along with worked examples illustrating the use of the procedures in this document.

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**		**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**
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 13370	Emission and control									
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									

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**
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 performance of buildings — Heat transfer via the ground — Calculation methods

1 Scope

This document provides methods of calculation of heat transfer coefficients and heat flow rates for building elements in thermal contact with the ground, including slab-on-ground floors, suspended floors and basements. It applies to building elements, or parts of them, below a horizontal plane in the bounding walls of the building situated

— at the level of the inside floor surface, for slab-on-ground floors, suspended floors and unheated basements;

NOTE 1 In some cases, external dimension systems define the boundary at the lower surface of the floor slab.

— at the level of the external ground surface, for heated basements.

This document includes calculation of the steady-state part of the heat transfer (the annual average rate of heat flow) and the part due to annual periodic variations in temperature (the seasonal variations of the heat flow rate about the annual average). These seasonal variations are obtained on a monthly basis and, except for the application to dynamic simulation programmes in Annex D, this document does not apply to shorter periods of time.

NOTE 2 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 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 10211, *Thermal bridges in building construction — Heat flows and surface temperatures — Detailed calculations*

ISO 14683, *Thermal bridges in building construction — Linear thermal transmittance — Simplified methods and default values*

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 and 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
slab on ground
floor construction directly on the ground over its whole area

3.2
suspended floor
floor construction in which the lowest floor is held off the ground, resulting in an air void between the floor and the ground

Note 1 to entry: This air void, also called underfloor space or crawl space, may be ventilated or unventilated, and does not form part of the habitable space.

3.3
basement
usable part of a building that is situated partly or entirely below ground level

Note 1 to entry: This space may be heated or unheated.

3.4
equivalent thickness
<thermal resistance>thickness of ground (having the thermal conductivity of the actual ground) which has the same thermal resistance as the element under consideration

3.5
steady-state heat transfer coefficient
steady-state heat flow divided by temperature difference between internal and external environments

3.6
internal periodic heat transfer coefficient
amplitude of periodic heat flow divided by amplitude of internal temperature variation over an annual cycle

3.7
external periodic heat transfer coefficient
amplitude of periodic heat flow divided by amplitude of external temperature over an annual cycle

3.8
characteristic dimension of floor
area of floor divided by half the perimeter of floor

3.9
phase difference
period of time between the maximum or minimum of a cyclic temperature and the consequential maximum or minimum heat flow rate

3.10
EPB standard
standard that complies with the requirements given in ISO 52000-1, CEN/TS 16628[6] and CEN/TS 16629[7]

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]

4 Symbols and subscripts

4.1 Symbols

Symbol	Quantity	Unit
A	area of floor	m^2
B	characteristic dimension of floor	m
d	total equivalent thickness	m
z	depth	m
H	steady-state heat transfer coefficient	W/K
h	height of floor surface above outside ground level	m
m	month number (m = 1 for January to m = 12 for December)	—
P	exposed perimeter	m
R	thermal resistance	$m^2·K/W$
U	thermal transmittance between internal and external environments	$W/(m^2·K)$
z	depth of basement floor below ground level	m
Φ	heat flow rate	W
λ	thermal conductivity	W/(m·K)
δ	periodic penetration depth	m
θ	temperature	°C
Ψ	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.

adj	adjusted
an	annual
b	basement, below ground level; width
bg	basement, including the effect of the ground
bsf	below suspended floor
C	cooling
e	external
ed	edge
eff	effective (including effect of ground and/or basement)
f	floor

fg	ground floor, including the effect of the ground
g	ground
H	heating
ins	insulation
int	internal
m	month; middle (of building)
p	constant pressure
pe	external periodic
pi	internal periodic
sog	slab on ground
si	internal surface
se	external surface
sus	suspended
ub	unheated basement, including the effect of the ground
ve	ventilation
vi	virtual
w	wall
wf	wall/floor junction
wg	wall including the effect of the ground
x	combined (through walls of underfloor space and by ventilation of the underfloor space)

5 Description of the method

5.1 Output

The output of this document is the thermal resistance and thermal transmittance of floors next to the ground and basements, together with coefficients that enable heat flows to be calculated on a monthly basis.

5.2 General description

Heat transfer via the ground is characterized by

— heat flow related to the area of the floor, depending on the construction of the floor,

— heat flow related to the perimeter of the floor, depending on thermal bridging at the edge of the floor, and

— annual periodic heat flow, also related to the perimeter of the floor, resulting from the thermal inertia of the ground.

The steady-state, or annual average, part of the heat transfer shall be evaluated using one of the methods described below.

a) A full three-dimensional numerical calculation, giving the result directly for the floor concerned: calculations shall be done in accordance with ISO 10211. The result is applicable only for the actual floor dimensions modelled.

b) A two-dimensional numerical calculation, using a floor that is infinitely long and has a width equal to the characteristic dimension of the floor (floor area divided by half perimeter, see 6.7.1); calculations shall be done in accordance with ISO 10211. The result is applicable to floors having the characteristic dimension that was modelled.

NOTE 1 The largest heat flows usually occur near the edges of the floor, and in most cases only small errors result from converting the three-dimensional problem to a two-dimensional problem in which the width of the building is taken as the characteristic dimension of the floor.

c) The area-related heat transfer calculated by the formulae given in this document (see Clause 7), together with the edge-related heat transfer obtained from linear thermal transmittances that are in accordance with any of the methods in ISO 14683 (numerical method, thermal bridge catalogues, manual calculation or default values).

NOTE 2 Linear thermal transmittance is calculated according to ISO 10211 or obtained from tables. ISO 13789:2017, Annex A has template for identifying sources of tabulated values of linear thermal transmittance, providing data for existing buildings, and identifying thermal bridges that can be neglected, with an informative default choice provided in Annex B.

For c), the steady-state part of the heat transfer is given by Formula (1):

$$H_g = A \cdot U + P \cdot \Psi_{wf} \tag{1}$$

where

H_g is the steady-state heat transfer coefficient via the ground, in W/K;

A is the area of floor, in m²;

U is the thermal transmittance between internal and external environments ($U_{fg;sog}$, $U_{fg;sus}$ $U_{bg;eff}$ or U_{ub}, depending on floor type; see Table 4), in W/(m²·K);

P is the exposed perimeter, in m;

Ψ_{wf} is the linear thermal transmittance of the wall/floor junction, in W/(m·K).

Method c) is applicable to a floor of any size or shape. U depends on floor size, but Ψ_{wf} is independent of the floor dimensions. Formula (1) is modified in the case of a heated basement (see 7.3.4) and in the case of application of Annex D (see D.1).

A template for defining whether method c) is allowed is given in Table A.2, with an informative default choice provided in Table B.2. A template for tabulated U-values is also given in Table A.2, with an informative default list in Table B.2.

5.3 Periodic coefficients

The document allows for different methods of allowing for phase differences between the annual cycle of temperature variation and heat flow (see C.1).

A template for defining which method is to be used is given in Table A.3, with an informative default choice provided in Table B.3.

6 Calculation of heat transfer via the ground

6.1 Output data

The output data are listed in Table 2.