Criteria and algorithms for

Certified Passive House Components – Column connection and wall junction

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Note: Certificates are currently only being issued for the 'arctic', 'cold', 'cool, temperate', 'warm, temperate' and 'warm' climate region.

Content

1 Preface

Passive House buildings provide optimal thermal comfort with minimum energy expenditure; they lie within the economically profitable range with reference to their life-cycle costs. To achieve this level of comfort and low life-cycle costs, the thermal quality of the components used in Passive Houses must meet stringent requirements. These requirements are directly derived from the Passive House criteria for hygiene, comfort and efficiency as well as from feasibility studies. The Passive House Institute has established component certification in order to define quality standards, facilitate the availability of highly efficient products and promote their expansion, and to provide planners and building owners with reliable characteristic values for input into energy balancing tools. In order to define a reliable quality, the Passive House Institute grants the quality seal "Certified Passive House Component – Column or wall connection".

2 Temperature criterion

Thermal bridges are thermal weak points in the building envelope. These weak points result in a higher heat flow and thus a lower temperature of the inner surface of the affected building component. Too low surface temperatures can have a disturbing effect on comfort and also cause high relative humidity, thus increasing the risk of mold and structural damage.

In order to prevent these effects, the temperature factor $f_{Rsi = 0.25\,m^2K/W}$ must not fall below a limit minimum value defined depending on the valid climate zone (see chapter 4 – Reference values):

$$\mathbf{f_{Rsi = 0.25\,m^2K/W} \geq f_{Rsi = 0.25\,m^2K/W,\,min}}.$$

(depending on the climate zone)

Calculation of f_{Rsi}

The minimal temperature factor $f_{Rsi = 0.25\,m^2K/W}$ defines the coldest point that can occur on the inner surface of a building system. For example, if the temperature factor is 0.7, 70 % of the temperature difference between the inside and outside air is still present on the inside surface. If the climate-specific temperature factor is achieved, mold and condensation can be avoided at normal outdoor temperatures, indoor temperatures and indoor humidity levels. The colder the outdoor climate, the higher the temperature factor requirement. 0.25 m²K/W in the index means that the heat transfer resistance to be applied is 0.25 m²K/W.

Calculation of the temperature factor f_{Rsi}: $$f_{Rsi} = \frac{\theta_{si} - \theta_a}{\theta_i - \theta_a}$$

θ_{si}: Minimal temperature of the inner surface determined via multidimensional heat transfer simulation [°C]

θ_a: Exterior temperature [°C]

θ_i: Interior temperature determined [°C]

3 Energy criterion

For the correct energy balance of a specific building, the detection and quantification of thermal bridges is crucial. Therefore the Passive House Institute includes thermal bridge loss coefficients of certified components as an essential part of the investigations in the certificates. For this purpose, the system structure is modeled in detail or appropriately simplified and the thermal parameters are determined by means of three-dimensional FEM heat flow simulation. The same system structure is simulated as a reference model with flank insulation (1.00 m length, 10 cm insulation thickness all around, thermal conductivity of 0.035 W/(mK) without a thermal separation element in order to determine the limit value requirement. The heat transfer coefficient of the considered elements of the thermal envelope must not exceed the recommended heat transfer coefficient for the respective climate zone (see section 4 Reference values).

3.1 Wall junctions

A maximum thermal bridge loss coefficient (ψ_{limit}) is defined as the limit value for certification. This corresponds to 80 % of the thermal bridge loss coefficient of the same construction in the reference model: The certified connection thus achieves a thermal improvement in relation to the reference construction.

$$\boldsymbol{\Psi_{limit} \leq \psi_{flanking\ insulation} * 0.80}$$

3.2 Column connections

The maximum point thermal bridge loss coefficient (χ_{limit}) for column connection situations corresponds to the point thermal bridge loss coefficient of the same construction in the reference model: The certified connection thus is at least equivalent to the reference construction.

$$\boldsymbol{X_{limit} \leq X_{flanking\ insulation}}$$

The PHI reserves the right to define further limit values for larger support diameters with regard to the absolute heat loss.

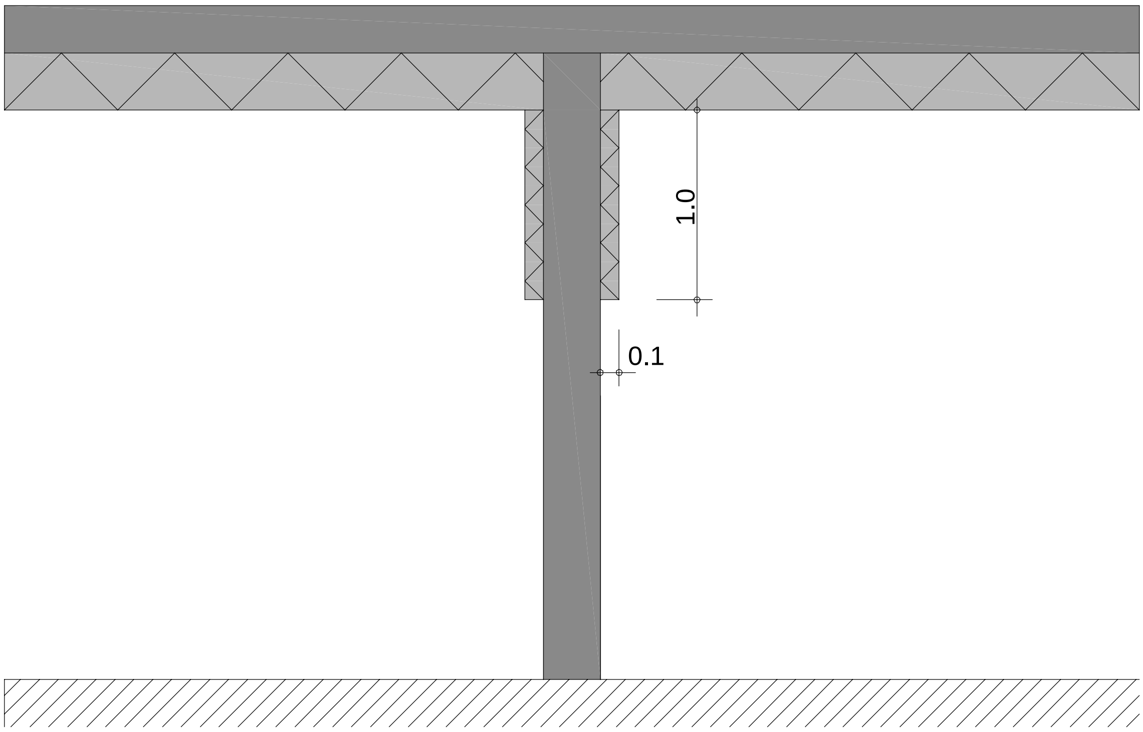

Figure 1: ***exemplary system structure for the Reference value determination***

Increased reinforcement in the piercing or connection area is taken into account by detailed modeling of the reinforcing bars or by increasing the equivalent thermal conductivity of the column or wall area.

In the slab area, an area of increased thermal conductivity is defined depending on the column diameter or the wall thickness, in order to take into account a possible increase in the reinforcement ratio, e. g. due to punching shear reinforcement. For this purpose, an area of increased thermal conductivity (λ = 4.9 W/(mK)) is defined around the column in a radius of three times the column diameter, both for the reference and for the component to be tested

Reinforcements in the wall and column are taken into account either via an addition to the thermal conductivity corresponding to the reinforcement proportion or via modeling of the reinforcing bars and consideration in the simulation.

The same procedure is used for walls resolved into columns – alternatively, realistic reinforcement can also be taken into account here depending on the expected load.

If not stated differently a concrete coverage layer of 2 cm is assumed as well as a thermal conductivity of 1.65 W/(mK) for the unreinforced concrete and 50 W/(mK) for the reinforcement (structural steel). In the certificate, the minimum column spacing for walls resolved into columns to achieve the requirements is shown.

4 Reference values

The requirements for the heat transfer coefficients are defined depending on the respective climate zone. The manufacturer is free to choose the system structure but the system structures must not exceed the minimum requirements according to Figure 1. The climate zone can be determined according to the classification of climates shown in Figure 2. The classification depends on the company location.

The minimum heat transfer coefficients depending on the climate zone are shown below.

Climate zone	**Hygiene criterion**	**Efficiency criterion**		**Temperature criterion**
	$f_{Rsi = 0.25\ m^2K/W}$ ≥[3]	U-value thermal envelope U_{opaque}	U-value thermal envelope $U_{opaque(I)}$ [1]	solely opaque details $f_{Rsi = 0.25\ m^2K/W}$ ≥[2]
	[-]	[W/(m²K)]	[W/(m²K)]	[-]
1 arctic	0.80	0.09	0.15	0.90
2 cold	0.75	0.12	0.20	0.88
3 cool, temperate	0.70	0.15	0.25	0.86
4 warm, temperate	0.65	0.25	0.42	0.82
5 warm	0.55	0.50	0.85	0.74
6 hot	none	0.50	0.85	0.74
7 very hot	none	0.25	0.42	0.82
1 U_{opaque} / f_{PHI}^2; $f_{R,\ PHI}$: Reduction factor for areas adjacent to ground and unheated basements: 0.6 2 $f_{Rsi = 0.25\ m^2K/W}$ ≥ See chapter 0, in cool temperate climates, the temperature criterion can also be met by achieving a minimum surface temperature of 17 °C under standard boundary conditions (see table of heat transfer resistances in Chapter 5)				

Table 1: Reference values – Component requirements depending on the climate zone

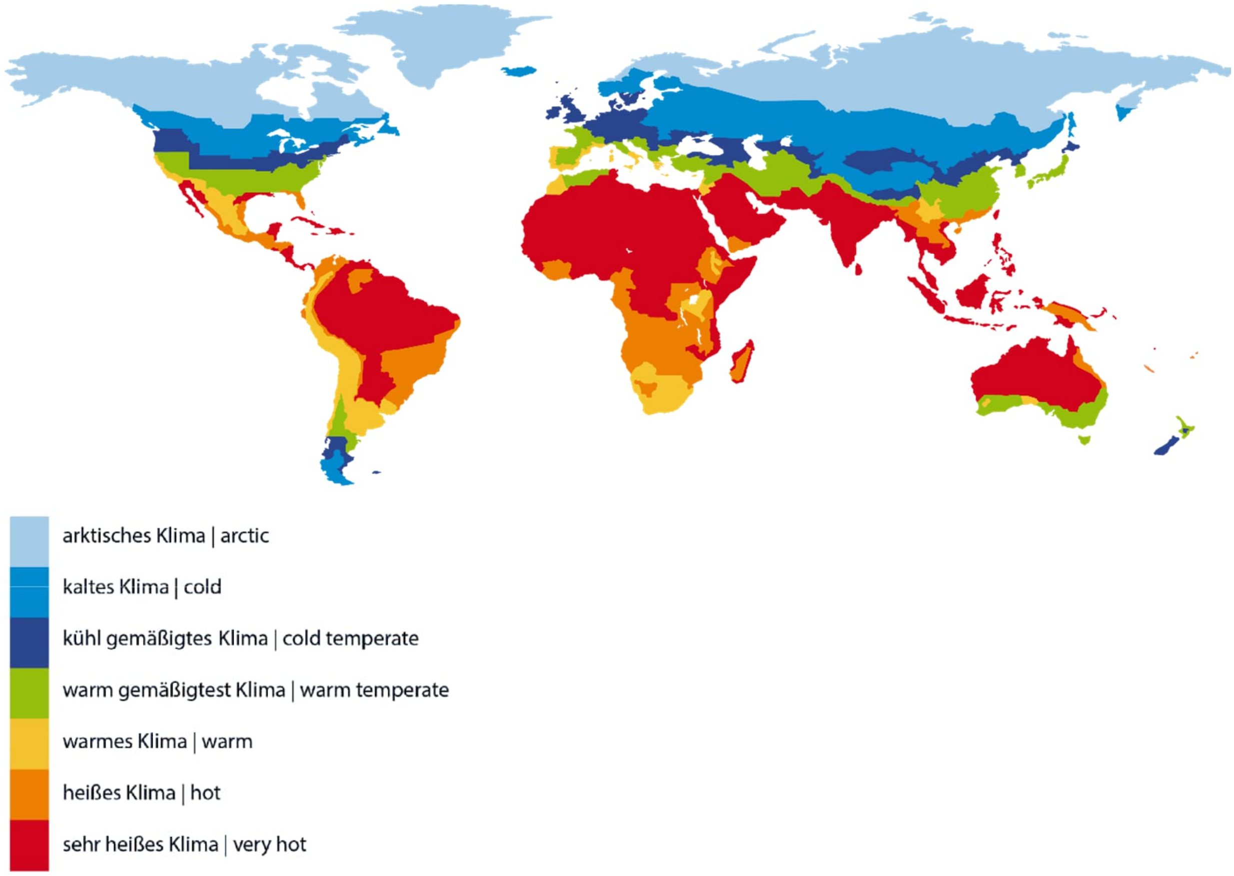

Figure 2: Climate zone map

5 Boundary conditions and determination of characteristic values

5.1 Temperature boundary conditions and heat transfer resistances

Outside temperature:	-10	°C
Temperature unheated basement:	+5	°C
Interior Temperature:	+20	°C

Temperature unheated rooms with contact to outside air: $\Theta_i - f_x$[1]$*(\Theta_i - \Theta_a)$ C°

Heat transfer resistance outside:	0.04	m²K/W
Heat transfer resistance outside (ventilated):	0.13	m²K/W
Heat transfer resistance inside:	0.13	m²K/W
Heat transfer resistance inside downwards:	0.17	m²K/W
Heat transfer resistance inside upwards:	0.10	m²K/W
Heat transfer resistance inside (f_{Rsi})	0.25	m²K/W

[1] The temperature correction factors f_x are used after consultation with the Passive House Institute. Alternatively 0°C can be used for unheated rooms.

More heat transfer resistance according to Figure 3 or after consultation with the PHI.

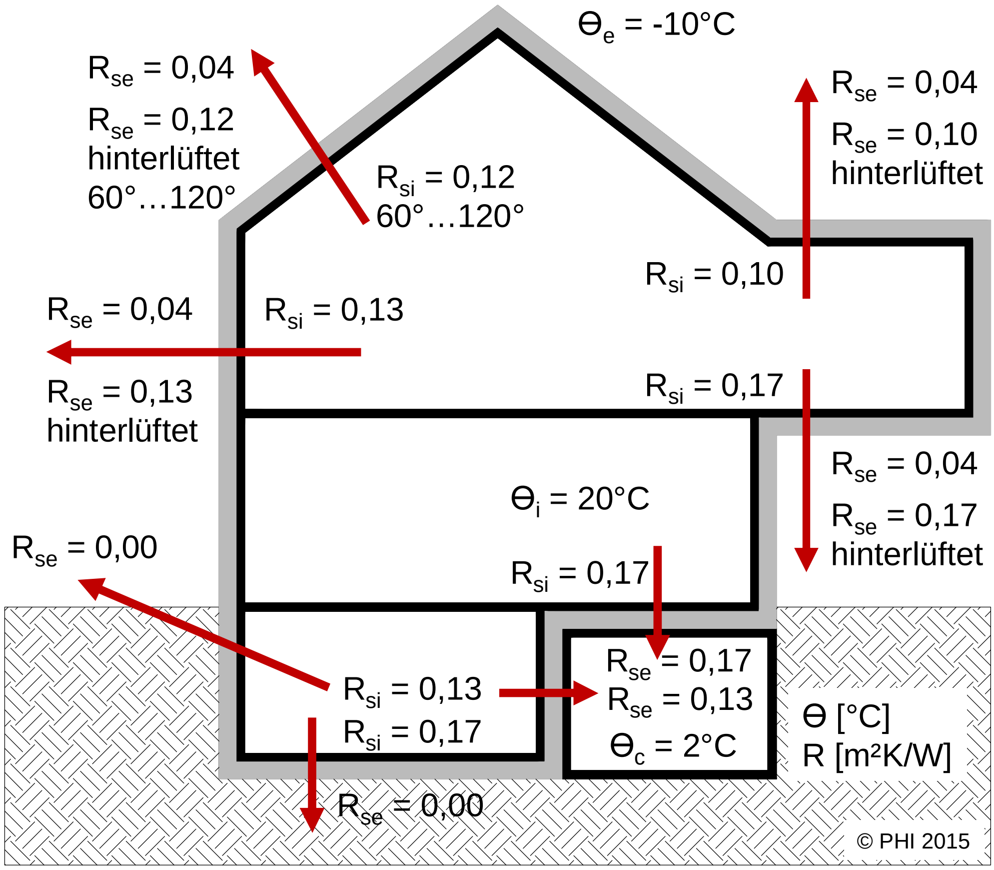

Figure 3: Heat transfer resistances

5.2 Material properties

In principle, the design value of the thermal conductivity is used in the calculation of the U-values and the heat flow simulation. This applies as long as no other regulations of the Passive House Institute are published.

If no design value is available, a nominal value of thermal conductivity determined by a recognized materials testing institute according to relevant standards can be used as a basis. Analogous to the design value supplements, this nominal value is usually multiplied by 1.25 and the result is used in the calculation.

The thermal conductivity is the nominal value determined from the measured data (from measurements on at least three different samples from different batches representative of the usual product variations, taking aging into account). For this purpose, a statistical evaluation, as described in ISO 10456:2007 Annex C, with a 90 % fractile is applied

6 Connection details – Possible situations

1. Column to unheated Basement/underground parking garage
2. Column to floor slab/ground
3. Walls resolved in columns to unheated Basement/underground parking garage
4. Walls resolved in columns to floor slab/ground
5. Bearers in unheated Basement/underground parking garage
6. More connection details can be examined after consultation of the PHI.

For the certification it is necessary that at least one connection detail achieves the requirements according to the certification criteria. Connections that do not meet the requirements are not shown in the certificate. Also a prerequisite is the classification as solid/reinforced concrete construction.

7 Documents required

The following documents should be provided to the PHI by the manufacturer for the calculation.

1. Detailed drawings of the claimed connection are submitted as dxf or dwg-files and as PDF-file or picture with the format pdf, bmp, jpg or png. Materials with different thermal conductivities have to be marked with different representations. Depending on the manufacturer-specific characteristics of the system the Passive House Institute may provide construction elements to be used. These can be specified, for example, for window frames, floor slab assemblies, or basement constructions for use during the certification process.
   Tables containing the design values of thermal conductivity, layer thicknesses and material designations of all component assemblies are to be provided. All materials, also outside the standard structures of the components, shall be listed and specified.
2. Design values of the thermal conductivities of the materials used for the selected superstructures and connections must be verified either according to DIN V 4108-4, DIN EN ISO 10077-2 or DIN EN ISO 10456 or, if deviating from these, on the basis of a general building authority approval or a general building authority test (including CE-marking or Ü-marking). If no design value of the thermal conductivity can be given, the PHI reserves the right to add a safety margin of up to 25 % to a nominal value. Different thermal conductivities of anisotropic materials depending on the heat flow direction are taken into account. Wood, for example, is given a factor of 2.2.
3. Exact details regarding substructures, center distances, spacers for the geometry, number of system-related surface units and additional necessary material us-

age when using such elements are necessary and, if necessary, must be represented by additional detailed drawings. In the case of systems with approval, the associated Technical Data Sheets shall be submitted

4. Verifications for insulation materials in contact with the ground with regard to water absorption in the case of long-term total immersion, water absorption by diffusion, closed-cell properties and the worst calculated value (design value) of the thermal conductivity in [W/(mK)]) to be used.
5. Complete general building approval or comparable documents for load-bearing insulation materials in contact with the ground.
6. 3D models in ACIS format if available, alternatively modeling can be commissioned.
7. Verifiable documentation for statics, load recording and air tightness concept.

8 Certification procedure