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Thermal bridges in the EBPD context: overview on MS approaches in regulations

Within the context of an energy performance regulation, it is essential to take transmission losses into account. If the building details are not well designed or carried out, thermal bridges can substantially increase the transmission losses. Additionally there is a risk of surface condensation and mould growth on the inner surfaces which can cause health and aesthetic problems. This document represents the status in the MS at the end of 2007.

1> Introduction

Thermal bridging increases the building energy demand for heating and cooling. For well insulated envelopes and buildings with an increased energy efficiency, the influence of thermal bridging on the energy consumption will be of a major importance. For such well insulated buildings, the ratio between the thermal bridging effect and the overall thermal losses increases compared to low or medium insulated buildings, and it is possible that the effect of thermal bridges on energy demand compensates or even overtakes, for instance, the energy gain provided by thermal solar collectors for domestic hot water [(1)]. The important impact of thermal bridging on the energy consumption is even more pronounced in the case of building retrofit, where solving thermal bridges often is an issue, especially where external insulation is not applicable because of architectural constraints[(2)] or not effective because of the presence of a lot of balconies.

Almost all MS building energy performance regulations deal with thermal bridges, but the approaches and, especially, minimum requirements may considerably differ.

This document summarizes the requisites and calculation procedures (detailed and simplified) in the MS participating in ASIEPI. In order to facilitate a correct comparison amongst MS regulations, the overview was splitted per geographical and climatic area: Northern, Central and Southern Europe.

2> The EBPD

The objective of the EPB Directive is to promote the improvement of the energy performance of buildings, taking into account outdoor climatic and local conditions, as well as indoor climate requirements and cost-effectiveness.

EUROPEAN COMMISSION
Directorate-General for Energy and Transport

The EPBD articles impose:

- the general framework for a methodology of calculation of the integrated energy performance of buildings;
- the application of minimum requirements on the energy performance of new buildings;
- the application of minimum requirements on the energy performance of large existing buildings that are subject to major renovation;
- energy certification of buildings; and
- regular inspections of boilers and of air-conditioning systems in buildings, and in addition, an assessment of the heating installations where the boilers are more than 15 years old.

3> Thermal bridges approaches in Member States Regulations.

3.1> Northern Europe

Denmark

National regulations consider the influence of thermal bridges in new buildings and in the renovation of buildings, in both cases using a simplified approach.

Simple thermal bridges are typically assessed by hand calculation, complex thermal bridges are assessed by means of a detailed numerical analysis. As regards the complex thermal bridges however, all typical solutions are covered by tabulated values available in standards, atlases or in brochures provided by building materials producers.

Regulations set specific requirements for thermal bridges. For extensions there are specific requirements for the U-values and in addition some maximum values for Ψ_k (value of the linear thermal bridge) which goes from 0.03 W/mK for window fittings to 0.15 W/mK for foundations.

For new buildings the maximum energy performance requirement has to be fulfilled and in addition some maximum values for thermal bridges are imposed: Ψ_k may be at maximum, which goes from 0.06 W/mK for window fittings up to 0.40 W/mK for foundations.

The realisation of details is supervised by public authorities during the project and checked by an energy consultant (from certification scheme).

Norway

Regulations distinguish between thermal bridges of little significance, occurring in building sections due to the way of construction (e.g. insulation between wooden studs, rafter joist) and which should be taken into account in the U-value, and thermal bridges of higher significance (e.g. edges of concrete floor going partly through an insulated wall), which should be evaluated separately.

Both issues are taken into account by explicit calculation which is obligatory for both new and renovated buildings.

In Norway there are two possible ways of satisfying the energy performance requirements of buildings, the framework requirements (which set a maximum energy performance level for entire buildings, according to building type) or the energy measure requirements (which set requirement levels for building envelope sections, e.g. U-values of walls and roofs, and installations (e.g. heat recovery system).

In the energy measure requirement model, the normalised thermal bridge value NKV = $(\Sigma\Psi^{*}l)/A_{BRA}$ should not exceed 0.03 W/m²K in small buildings and 0.06 W/m²K in larger buildings, where Ψ is the linear thermal transmittance, l is the length of the thermal bridge and A_{BRA} is the available heated area (area within the exterior walls).The wall, roof, and floor U-value requirements are 0.18, 0.13, and 0.15 W/m^{2}K, respectively. In additions there are also requirements related to the ventilation system, external shading, and setback of night time and weekend interior temperature.

For the framework requirements model there is no specific requirement related to the thermal bridges, but instead maximum thermal performance levels are specified for the whole building. Maximum U-value levels are however specified for the various building envelope parts.

Requirements regarding risks of surface condensation and mould growth on the inner surfaces will also limit the size of the thermal bridges. The execution of building details is not checked by authorities.

Finland

National regulations consider the influence of thermal bridges only for new buildings. The approach is a simplified one.

Simplified method 1: for a layer in a structure composed of different materials with different thermal conductivities parallel to the thermal flow: if the λ-ratio (the highest divided by the lowest thermal conductivity of two adjacent layers respectively) is smaller than 5, then the area weighted λ-value can be used as thermal conductivity of that layer. Insulation between wood studs is a typical example. This kind of layer is treated as an “averaged mixture” of two materials in U-value calculations

Simplified method 2: if the previously defined λ-ratio is higher than 5 the detail should be handled as thermal bridge. The effect of the presence of a poorly insulating material on the energy performance of the whole structure has to be modelled with an appropriate (e.g. 3D-calculation) method or with measurements in order to obtain the linear or point thermal transmittance of the thermal bridge. These thermal transmittances summed up over all thermal bridges are added to the U-value:

$$\Delta U_{\Psi X} = \Sigma\Psi_k (l_k / A) + \Sigma X_j (n_j / A)$$

The Finnish building code does not impose maximum values for thermal bridging, but the structures have to be designed in such a way that the overall heat transfer coefficient of the building design is lower than the reference design heat transfer coefficient calculated with the tabulated U-values from the building code and with the design ventilation rate. Structural details also have to be designed in order to avoid condensation within any part or on any surface of the structure.

The general realisation of details is not supervised by authorities, but an inspector may give guidelines for good practice.

3.2> Central Europe

Belgium

The 3 regions in Belgium are responsible for the implementation of the EPBD. The Flemish Region imposes EPBD requirements since 2006. The other regions are preparing similar regulations.

It is expected that in the near future the regulations will consider the influence of thermal bridges in new buildings applying explicit calculation and simplified approaches.

Five different approaches have already been set in the Flemish calculation method; however the implementation is postponed:

1. The overall transmission heat losses through the building envelope can be obtained from a 3D numerical simulation of the whole building according to the CEN/ISO standards.
2. Thermal bridging can be taken into account by adding the term $\Sigma\psi^*l+\Sigma\chi$ to ΣU^*A in order to obtain the overall transmission heat transfer coefficient. Ψ and χ may be obtained by numerical simulation (CEN/ISO standards) or from tabulated values. User friendly software coupled to a database of details is developed for this approach
3. In case all details in a building are realized according to the regulations, it is allowed to apply to the overall insulation level (K-level) a default value accounting for the effect of thermal bridging on the transmission heat losses. For this approach a set of maximum ψ-values and reference details are developed. The default value will most likely correspond to about 5% of the present requirement for the overall insulation level of a new construction.
4. In case the details of possible thermal bridges correspond only partially to regulations, a separate 2D/3D determination of the ψ- or χ-values for those details is required.
    1. The following losses have to be added:
        a. The default value as specified in 3, which is covering the details according to the regulations;
        b. The influence of the building details which do not comply with the norms set by the authorities.
5. In case the effect of thermal bridges is not taken into account at all, a penalising default value of 10K-points for the extra transmission losses due to thermal bridging has to be added to the K-level (typical Belgian overall transmission heat loss indicator for the building envelope). 10K-points corresponds to more than 20% of the present requirements for new constructions.

Maximum values for thermal bridges are only used in methodology 3 but not as absolute limit values to the thermal bridges.

An energy performance certificate is required for all new buildings for which the energy performance has to be calculated, and for which a building permit has been requested. The drafting and delivery of this energy performance certificate is part of the procedure related to the *'EPB-declaration'* of the executed works after construction. Any aspect of the as-built declaration (thus including the thermal bridges in the future) can be subject to control (and sanctioning with administrative fines) by the public authorities.

The Netherlands

National regulations only consider the influence of thermal bridges in new buildings. This is done via the EP standardisation and an additional standard concerning thermal insulation of buildings [11], which contains an explicit calculation method as well as a simplified approach. This simplified method uses an addition to the U-value (with $\Delta U = 0.10\ W/m^2K$). The detailed method is devised according to CEN standards on thermal bridges: the value of linear thermal bridge (ψ-value) is calculated and

added to energy losses by transmission.

The authorities set no maximum values concerning thermal bridges.

Officially the realisation of details is controlled by the authorities, but the realisation of the details is usually not checked.

Germany

With regard to structural thermal bridges, the national standards impose that the impact of thermal bridging must be kept as low as possible.

The remaining influence is taken into account in one of the following ways:

› Overall increase in the heat transfer of the building surface areas by ΔU_{WB} = 0.05…0.15 W/m^{2}K, according to DIN 4108 and DIN V 18599, with:

- ΔU_{WB} = 0.10 W/m^{2}K as standard value for new constructions
- ΔU_{WB} = 0.05 W/m^{2}K if realised at least as good as example details in DIN V 4108, supplementary sheet 2
- ΔU_{WB} = 0.15 W/m^{2}K for existing buildings with internal insulation (DIN V 18599-2).

› Accurate analysis of thermal bridges in accordance with agreed European calculation standards (DIN EN ISO 10211-1/2) or example details with given ψ- or χ-values.

The standards consider the influence of thermal bridges in new buildings and in the renovation of buildings, applying in both cases explicit calculation methods and simplified approaches.

The dimensionless temperature factor f_{Rsi} should be higher than 0.7.

The realisation of details is usually not checked by the authorities.

France

Legal standards consider the influence of thermal bridges in new buildings.

Explicit calculation methods or thermal bridges atlas (Th-U) can be used to determine the linear thermal transmittances. The method used is based on the standards NF EN ISO 10211, NF EN ISO 13370, NF EN ISO 6946.

French standards regarding renovated buildings are under elaboration, and will be available in 2008 (the influence of thermal bridge will be considered).

With present requirements, the linear thermal transmittance may not exceed 0.65 W/mK for dwellings, 1 W/mK for apartment buildings and 1.2 W/mK for other buildings.
The realisation of details is not checked by the authorities.

Poland

Standards consider the influence of thermal bridges in new buildings and renovated buildings, both with simplified approach or explicit calculation.

Simplified method:
A correction factor is added to the U-value:

› exterior wall with openings for windows and doors: ΔU=0,05 W/m²K,

› exterior walls with openings for windows and doors with balcony cantilever passing through the wall ΔU=0,15 W/m²K

Detailed method: calculations according PN-EN ISO 14683

There are only limits for maximum U-values (that take into account

thermal bridges).

The design is checked by another designer, both are responsible for the correctness of the design.

The building is checked administratively by the authorities before issuing building use permit. Checking is based on formal documentations, so no real test is performed.

Czech Republic

Regulations consider the influence of thermal bridges in new buildings and in the renovation of buildings, applying in both cases explicit calculation methods and simplified approaches.

Methods are described in standards CSN EN ISO 10211-1 Thermal bridges building constructions - Basic calculation methods CSN EN ISO 10211-1, CSN EN ISO 10211-2, CSN EN ISO 14683, CSN EN ISO 13370.

The different values required and recommended for linear and point thermal bridges are:

- Linear: $\Psi_{k,N}$ = 0,10 …0,60 W/mK (required); $\Psi_{k,N}$ = 0,03 …0,20 W/mK (recommended).
- Punctual: $\Psi_{k,N}$ = 0,90 W/K (req.); $\Psi_{k,N}$ = 0,30 W/K (rec.).

In special cases the building is checked by the authorities by means of infrared thermography.

3.3> Southern Europe

Greece

At the end of 2007 Greece was still in the process of setting up the EPBD regulation. The currently existing national regulation does not fulfill the EBPD requirements and does not yet consider the influence of thermal bridges in buildings.

Spain

Country standards [9,10] consider the influence of thermal bridges in new buildings and in buildings which are being renovated, applying in both cases explicit calculation methods and simplified approaches.

The simplified method consists of an addition to the U-value in order to take thermal bridging into account and of a proof that there is no condensation risk. The simplified method is based on the selection of the thermal bridge type from an atlas.
The general method consists in the assessment of the linear thermal transmittance (ψ-value) and indoor surface temperature, using a software like KOBRA.

The standards do not set a maximum value for thermal bridges, but there is a minimum value of the indoor surface temperature in order to avoid condensation risks.

When the constructive detail is not included in the atlas, the calculation of its linear thermal transmittance and indoor surface temperature must be included in the project.

Portugal

National authorities consider the influence of thermal bridges for new buildings and for the renovation of buildings. In both cases a simplified

approach is used.

All thermal bridges are to be calculated individually, but losses are treated in a simplified manner by using tabulated values, no calculations are needed.

A maximum value for thermal bridges is not given for linear thermal bridges, but only for areas (e.g. a structural beam inserted within a wall): the U-value taking into account thermal bridging may not be higher than twice the U-value of the adjacent wall.

The control is carried out during design and realisation. During the design stage, the design must be submitted to the local authority with the request for a building permit. 1:50 scale drawings of typical situations of thermal bridges (e.g. joint of two vertical walls, verandas, contact with soil, structural beams within walls, etc.) should be included. The qualified expert checks if they meet the requirements of the regulations and if they are correctly accounted for in the thermal calculations.
During realisation, the builder is supposed to prove how the details of the thermal bridges were constructed (e.g. with pictures). In case of doubt, any other means can be used (e.g. thermography, at builders expense) to make sure that the thermal characteristics of the detail "as built" are according to design specifications.

Italy

The regulation considers the influence of thermal bridges only for new buildings, applying both a detailed calculation method and a simplified approach.

Detailed method: according to UNI EN ISO 10211 - 1/2.
Simplified approach: U-value increment according to walls typology and based on the standard UNI EN 14683.

The Italian regulation (DM 192/2005, DM 311/2006) does not impose a maximum value for thermal bridges. It considers a thermal bridge *acceptable* when its U-value - calculated considering it as a fictitious wall – does not exceed by more than 15% the transmittance of the closest wall: in this case the thermal bridge can be ignored; otherwise the weighted average transmittance of the wall and thermal bridge (considered as a fictitious wall) has to be considered and compared with maximum acceptable values for wall transmittance.

During the project, designers have to present a design report to the local authorities including an annex about the envelope characteristics in order to get a permit to build or refurbish. In principle controls on the building site are foreseen, but in practice each local administration has its own procedure.

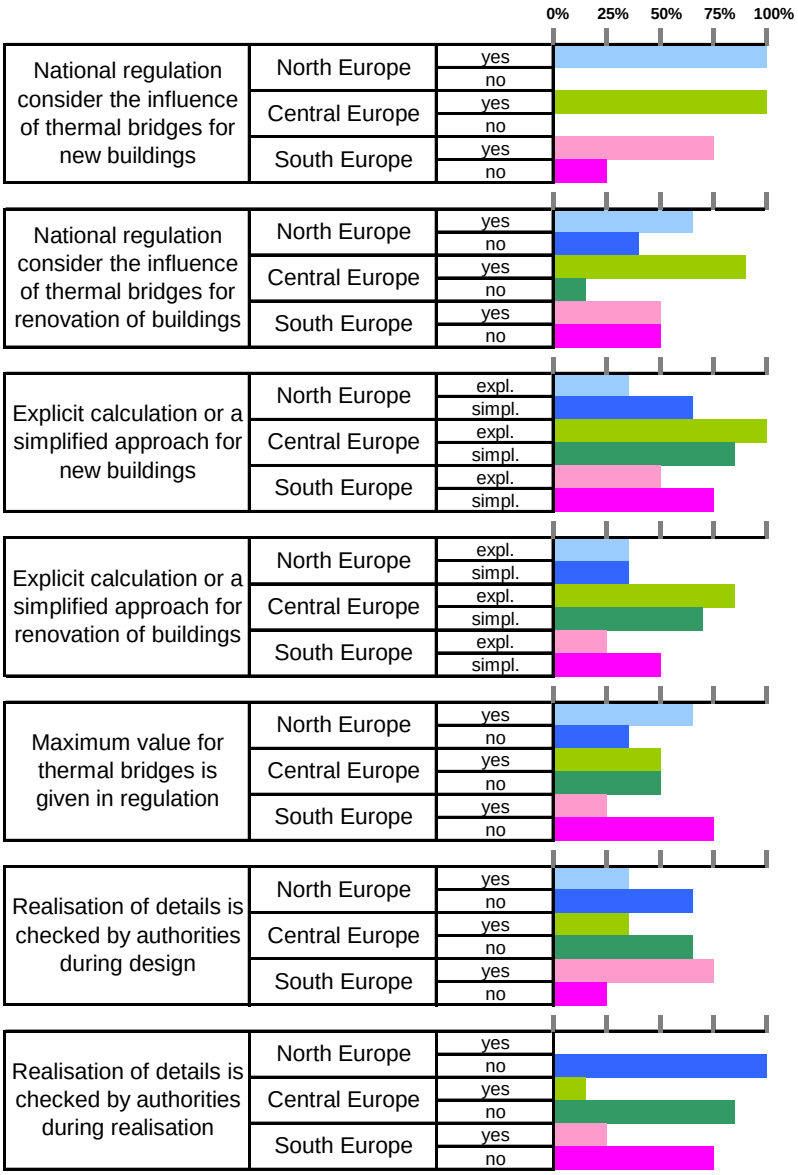
4> Conclusions

This paper analysed if and how Member States deal with thermal bridges in their calculation procedures.

The following table shows that all countries in Northern and Central Europe are dealing with the problem as far as new constructions are concerned. This is not the case for renovation projects.
Specific attention has been given to collecting information on simplified approaches: a simplified approach is most used in Northern and Southern Europe. Only Finland applies special assessment methods (dependent on the λ-ratio).

There are many methods to deal with the maximum value for thermal bridges in regulations: in Germany the dimensionless temperature factor f_{Rsi} is used, in Denmark and Czech Republic a ψ_{max} value is set depending on the type of join, in France the ψ_{max} depends on the type of building.

In addition, compliance and control issues were analyzed: the realisation of details is sometimes checked during the design phase, especially in Southern Europe.



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