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THE INFLUENCE OF LINEAR THERMAL TRANSMITTANCE OF THERMAL BRIDGES ON THE ENERGY PERFORMANCE CLASS OF BUILDINGS – SIMPLIFIED METHOD

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ABSTRACT

Thermal bridges have significant influence at calculation of the energy performance classes of buildings. This especially applies to countries where energy performance classes of buildings are determined based only on energy consumption for heating (such as Serbia, Bosnia and Hercegovina, Croatia...). Significant differences arise in determining the heat losses due to thermal bridges. Differences that can occur by using simplified methods depending on national recommendations of different countries are shown in this article.

Key words: *thermal bridges, simplified method*

INTRODUCTION

The influence of thermal bridges in the overall calculation of the annual thermal energy needed for heating is not negligible. There are numerous standards also given to conduct their calculation. Standard EN ISO 10211: 2007 (Thermal bridges in building construction - Heat flows and surface temperatures - Detailed calculations) provides a detailed calculation of heat losses due to thermal bridges. A detailed computation is often complicated and time consuming, requires specific knowledge and utilization of certain software, therefore many times results are obtained using a simplified calculation offered in standard EN ISO 14683: 2007 (Thermal bridges in building construction - Linear thermal transmittance - Simplified methods and default values). The calculation is further simplified by national regulations giving an approximate method for determination of overall heat losses due to thermal bridges. The paper presents the influence of thermal bridges at calculation of the energy performance classes of buildings in case of a free-standing residential building (the building with one apartment) depending on national regulations of the following countries: Serbia, Croatian, Bosnia and Herzegovina, Montenegro, Hungary and Macedonia. Comparison was made for two objects of similar shape and size, but with different thermal envelope.

BACKGROUND INFORMATIONS ABOUT ANALYZED BUILDINGS

At determination of the energy performance classes of buildings thermal bridges can have a significant impact [1,2,3]. Consequently, during the design, it is necessary to pay special attention to the proper solution of the contentious places, so the influence of thermal bridges would lessen.

Details of the observed building 1 and building 2, necessary information about applied insulations and the heat transfer coefficients are given in Table 1. and Table 2.

Table 1. Thermal envelope description and overall heat transfer coefficients for building 1

Thermal envelope part	Constituent elements	U (W/m^{2}K)
External walls	Ytong block 25 cm Extruded polystyrene 25 cm	0,112
Floor on the ground	Extruded polystyrene 20 cm. The foundation walls and foundations are insulated with an external layer of styrodur 20.0 cm - around the building	0,132
Ceiling under unheated roof space	Mineral wool 40 cm	0,093
Pitched roof above heated space	Mineral wool 40 cm	0,099
Windows	Doors and windows have a special case for passive houses and triple low-e glass filled with xenon 4 + 8 + 4 + 8 +4	0,67-0,81
Doors		0,69-0,72

Table 2. Thermal envelope description and overall heat transfer coefficients for building 2

Thermal envelope part	Constituent elements	U (W/m^{2}K)
External walls	Mineral wool 10 cm	0,253
Floor on the ground	Extruded polystyrene 12 cm	0,296
Ceiling under unheated roof space	Mineral wool 20 cm	0,161
Pitched roof above heated space	Mineral wool 24 cm	0,138
Windows	Windows and doors are made of laminated wood, double low-e glass filled with xenon 4+12+4	1,10-1,32
Doors		1,22-1,26

In order to gain the visual impression of the subject buildings, the appearance of the building 1 and building 2 are shown in Figure 1.

Figure 1. Building 1 and 2

SIMPLIFIED METHODS DEFINED BY NATIONAL REGULATIONS

Serbian national rulebook on the energy efficiency of buildings [4] have a recommendation, that the influence of thermal bridges should be count, with an increase of transmission heat loss for the value of linear heat transmission, by amount of 10% of the total thermal envelope.

In Croatia, [5] the impact of thermal bridges depends on the manner in which they are solved, so there are two cases:

1. If the potential thermal bridges are designed in accordance with the best practice solutions and details of thermal bridges, then instead of a detailed calculation, the influence of thermal bridges can be obtained by increasing of the heat transfer coefficient U for each part of the thermal envelope of the building 0,05 W / m^2K, except for the openings and other transparent parts.
2. If the solution of thermal bridge is not shown in the thermal brigde catalogue then the influence of thermal bridges can be considered by increasing the heat transfer coefficient U for each part of the thermal envelope of the building for 0,10 W / m^2K.

Bosnia and Herzegovina [6] and Montenegro [7] have the same criteria similar to Croatian's, with only difference that the increase in heat transfer coefficient by U 0,05 W / m^2K is counted for the entire thermal envelope (inclueding transparent and non-transparent parts) if thermal bridges are solved in accordance with the solutions shown in the catalogue, or if they are insulated in accordance with the "good" practice solutions. Otherwise, increase of the heat transfer coefficient U is 0,10 W/m^2K.

Hungarian regulations are significantly more detailed [8]. Table 3. shows the assessment of the impact of thermal bridges.

Table 3. Influence of thermal bridges

Thermal envelope part	Small impact of thermal bridges	Moderate impact of thermal bridges	Significant impact of thermal bridges
External wall	<0,8	0,8-1,0	> l,0
Flat roof	<0,2	0,2-0,3	> 0,3
Walls in attics separating heated and unheated space	<0,4	0,4-0,5	>0,5

Recommendations for parts of thermal envelope are given in Table 4., depending on the impact assessment of thermal bridges.

Macedonian regulations [9] observe otherwise the thermal bridge issues. The basic parameter is the position of the thermal insulation layer in the building element (from the outside, in the middle or on the inside of the thermal envelope). According to Dr. Peter Nikolovski, the reason for this approach lies in the fact, that Macedonia is a region with high seismic activity, however, because of the strict regulations, using structural elements of reinforced concrete which has extremely poor thermal insulating properties [10]. Macedonian regulations also distinguish two main cases for determining thermal bridges as follows:

1. At buildings with continuous insulation on the outside, the impact of thermal bridges are compensated by increasing of the heat transfer coefficient U for each part of the thermal envelope of the building by 15%.

2. At buildings where the insulation is in the middle or on the inside of the thermal envelope part, or if the thermal insulation layer is discontinues (for example, console balcony), the impact of thermal bridges are compensated by increasing of the heat transfer coefficient U for each part of the thermal envelope of the building by 35%.

Table 4. Recommendations for the correction coefficient values

Part of thermal envelope			Correction coefficient
External walls	External or internal wall with continuos thermal insulation	With small impact of thermal bridges	0,15
		With moderate impact of thermal bridges	0,20
		With significant impact of thermal bridges	0,30
	Other external walls	With small impact of thermal bridges	0,25
		With moderate impact of thermal bridges	0,30
		With significant impact of thermal bridges	0,40
Flat roofs		With small impact of thermal bridges	0,10
		With moderate impact of thermal bridges	0,15
		With significant impact of thermal bridges	0,20
Walls in attics separating heated and unheated space		With small impact of thermal bridges	0,10
		With moderate impact of thermal bridges	0,15
		With significant impact of thermal bridges	0,20
Ceilings			0,10
Arcade			0,10
Floor above basement		insulation on the upper side	0,20
		insulation on the underside	0,10
The walls between heated and unheated space			0,05

RESULTS

In Table 5. and Table 6. linear transmission heat losses are compared related with total and with surface transmission losses. Additionally, the final annual energy required for heating and the energy performance classes of buildings are also presented. All calculations are made in accordance with the related EN standards [11,12,13,14,15,16,17].

Table 5. Results based on simplified methods according to national regulations for building 1

Country	Percentage participation of linear transmission heat losses related to total transmission losses	Percentage participation of linear transmission heat losses related to surface transmission losses	Annual energy use for heating	Energy performance class
Serbia	35,65	55,40	21,37	B
Croatia	25,24	33,77	17,28	B
Bosnia and Herzegovina & Montenegro	23,84	31,30	16,81	A
Hungary	36,95	58,61	21,98	B
Macedonia	13,03	14,98	13,73	A

Table 6. Results based on simplified methods according to national regulations for building 2

Country	Percentage participation of linear transmission heat losses related to total transmission losses	Percentage participation of linear transmission heat losses related to surface transmission losses	Annual energy use for heating	Energy performance class
Serbia	25,45	34,15	46,20	C
Croatia	13,76	15,96	38,89	C
Bosnia and Herzegovina and Montenegro	12,59	14,40	38,23	C
Hungary	26,20	35,51	46,75	C
Macedonia	25,92	35,00	46,54	C

COMPARISON OF THE RESULTS

From the foregoing it can be concluded that thermal bridges play an important role in determining the annual final energy needed for heating and the energy performance class of buildings. In the first case, thermal bridges impact was even reflected in the energy performance classes of buildings.

Different countries treat differently the influence of thermal bridges. Some regulations are detailed while others are simplified to the maximum. In some countries, such as Macedonia, the influence of thermal bridges are taken into account by increasing the overall heat transfer coefficient U in percentage, while in other countries the influence of thermal bridges is compensated by increasing the overall heat transfer coefficient U for a constant value. Certainly, these differences depend on the very specific climatic characteristics, typical for the country but it should be noted that in analyzed study are all neighbouring countries which, although have different climatic characteristics, still adjoining.

It can be concluded that heat losses due to linear thermal bridging in well-insulated buildings make up to 36% of the total transmission losses, i.e. make up to almost 60% compared to surface transmission losses. On the other hand, when buildings are insulated in accordance with the recommendations that meet the minimum energy performance class of C, these losses sum about 25% of total, or 35% compared to surface transmission losses. It is logical to expect less heat losses due to linear thermal bridging in well-insulated buildings compared to the less insulated buildings but raises the question of the correctness of the method.

CONCLUSION

Speed of calculating influences of thermal bridges is one of the advantages of approximate methods given by national regulations. By analyzing a large number of different buildings, a correlation could be found that shows the applicability of the assumptions and values which are desirable to implement in calculation. This applies particularly to the conventional buildings that are designed to meet the minimum requirements for new buildings, that is for buildings that meet energy performance class C.
It is necessary to introduce more parameters in the analysis of thermal bridges such as the position of the thermal insulation in the element of thermal envelope, insulating layer continuity, type of element in thermal envelope, etc. In essence, for buildings that are insulated to meet energy performance class C, calculation of thermal bridges could be able to evaluate in accordance with the standard EN ISO 14683: 2007 with the adaptation of national recommendations in accordance with the technical solutions typical for the region.

For buildings designed to be energy efficient, which are designed and constructed to reduce the maximum thermal bridges impact, this method is not suitable. For such buildings it is necessary to do a detailed calculation in accordance with the standard EN ISO 10211. Of course, the most reliable data is obtained by observing the power consumption of the building that could be one of the next targets.

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