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POREĐENJE TRI METODE PRORAČUNA ENERGETSKIH CERTIFIKATA U SLOVENIJI

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Apstrakt:

Kako bi dobili ovlaštenje za izradu energetskih certifikata u Sloveniji, kandidati moraju pohađati propisanu obuku i položiti ispit. Pojednostavljena metoda proračuna toplotnih gubitaka koja se podučava na ovoj obuci zanemaruje toplotne mostove, što pouzdanost rezultata čini upitnim. U ovom radu uporedili smo tri metode proračuna toplotnih gubitaka kod „tipične" porodične kuće. Prva metoda predstavlja prethodno pomenuti pojednostavljeni proračun koji koristi korekcijski faktor; druga uzima u obzir toplotne mostove, koristeći numerički dobijene vrijednosti linijskih koeficijenata prolaza toplote, a treća koristeći zadane vrijednosti ovih parametara. Uzimajući u obzir da druga metoda daje najpreciznije rezultate, utvrdili smo da su rezultati prve metode preveliki, ali ipak manji nego rezultati dobijeni trećom metodom.

Ključne riječi: energetski certifikat, toplinski gubici, toplinski most

COMPARISON OF THREE CALCULATION METHODS OF ENERGY PERFORMANCE CERTIFICATES IN SLOVENIA

Abstract:

In order to get the authorization for issuing energy performance certificates in Slovenia, the expert candidate has to attend the prescribed course and pass the exam. The simplified method for heat losses calculation that is taught at this course neglects the thermal bridges, raising concerns whether the calculation results are reliable. In this paper we have compared three methods for calculation of thermal losses for a "typical" family house. The first is the above mentioned simplified calculation using a correctional factor; the second takes into account the thermal bridges, using linear thermal transmittances obtained by numerical calculation, and the third takes into account the thermal bridges, using default values for linear thermal transmittances. Noting that the second method returns the most exact values, we have found that the first method results are too large, yet still smaller than the third method results.

Keywords: energy performance certificates, thermal losses, thermal bridge

1. INTRODUCTION

Energy demand is one of the biggest challenges of the European Union (EU) today. Because of EU dependence on foreign energy sources as well as the energy usage negative impact on local environment and global warming, for decades the aim of EU politics has been to curb its consumption.

The most effective way to achieve this goal is to increase energy efficiency. According to data from 2012, heating and cooling represents 50% of all EU final energy consumption and more than 60% of that accounts for building heating and cooling [1][2]. It is therefore not a great surprise that the focal point of the efforts is the building heating and cooling. In fact, 76% of energy efficiency public funding within EU goes to buildings energy efficiency [3].

Part of these efforts goes to legislation, of which currently the most important are Directive 2010/31/EU on the energy performance of buildings [4] and Directive 2012/27/EU on energy efficiency [5]. Among others, the former has introduced the energy performance certificates as a certificate recognized by a Member State or by a legal person designated by it, which indicates the energy performance of a building or building unit. However, the directive is vague about the methodology of calculation and authorizes member states to determine it.

Slovenia is regulating the issuing of energy certificates by three separate laws, one making energy performance certificates obligatory (Ur. l. RS, 12/2014), one specifying calculation methodology (Ur. l. RS 92/2014), and one establishing system of licenses for the experts issuing energy performance certificates (Ur. l. RS 6/2010 and 23/2013). In general, it is prescribed that energy certificates are produced in accordance with existing regulations for the calculation of thermal losses, which closely follow the procedures prescribed by various ISO standards.

Part of the license procedure requires the expert candidates to attend the prescribed course and pass the exam. Surprisingly, the course excludes calculation of the thermal bridges contribution. In this article, we will analyze the impact of this simplification on the value of the calculated thermal losses for an example of a simple building.

2. CALCULATION METHODS

According to ISO 13789 [6], the four principal contributions to thermal losses are direct thermal losses, thermal losses through the ground, thermal losses through ventilation and thermal losses through unconditioned spaces. In this article we shall consider only the former two. Expression for direct thermal losses are described by direct heat transfer coefficient

$$H_{\mathrm{D}} = \sum_{\mathrm{i}} A_{\mathrm{i}}\, U_{\mathrm{i}} + \sum_{\mathrm{j}} l_{\mathrm{j}}\, \Psi_{\mathrm{j}} + \sum_{\mathrm{k}} \chi_{\mathrm{k}}\,, \qquad (1)$$

where U and A are thermal transmittance and area of the wall, respectively, Ψ and l are linear thermal transmittance and the length of the linear thermal bridge, respectively, and χ is point thermal transmittance of the point thermal bridge. Note that according to ISO 14683 [7], the third term in (1) due to the point thermal bridges, insofar as they result from the intersection of linear thermal bridges, can be generally neglected.

The second and the third term in (1) are corrections due to thermal bridges. For example, structural thermal bridges are locations on the thermal envelope where thermal transmittance is generally significantly higher than in its immediate neighbourhood. On the other hand, geometric thermal bridges account for the difference in heat transfer calculation due to the usage of the external or internal building dimensions [8]. In the case of the external dimensions, calculation areas in the first term represent upper limit values and the corresponding heat transfer coefficient is larger than the exact value. On the other hand, in the case of the internal dimensions, calculation areas represent lower limit values and the corresponding heat transfer coefficient is smaller than the exact value. Since linear thermal transmittances for external dimensions are smaller than zero, $\Psi_{\mathrm{e}} < 0$, and linear thermal transmittances for internal dimensions are larger than zero, $\Psi_{\mathrm{i}} > 0$, taking into account geometric thermal bridges leads to the same exact result for thermal losses, regardless of the dimension system.

Slovenian legislation, in particular technical guidelines TSG-1-004:2010 [9], allow the simplified calculation. If all linear thermal transmittances for external dimensions are $\Psi_{\mathrm{e}} < 0.2\mathrm{W}/(\mathrm{m}\cdot\mathrm{K})$ according to ISO 14683, thermal bridges can be disregarded and the thermal transmittance of the whole thermal envelope is increased by $\Delta U_{\Psi} = 0.06\mathrm{W}/(\mathrm{m}^2\mathrm{K})$, leading to the simplified form for direct heat transfer coefficient

$$H_{\mathrm{D}} = \sum_{\mathrm{i}} A_{\mathrm{i}} \left(U_{\mathrm{i}} + \Delta U_{\Psi}\right). \quad (2)$$

In the prescribed course for the licenses, expert candidates are taught to use the above described simplified calculation regardless of the value of linear thermal transmittances, i.e. even when thermal bridges are not being well addressed. Yet, to get the upper limit thermal losses, they are to be calculated using external dimension system. To our knowledge all energy certificates in Slovenia are calculated according to these directions. But in most practical situations, the condition of the technical guidelines for the simplified calculation is not fulfilled, raising concerns whether the results are reliable.

On the other hand, one of the practical problems is how to obtain reliable values for linear thermal transmittances. ISO 14683 [7] provides several methods, of which the numerical calculations according to ISO 10211 [10] (typical accuracy ± 5 %) are the most precise and the default values provided by the standard itself (typical accuracy 0 % to 50 %) are the least precise. In this article we shall compare the results of the three calculations:

- the simplified calculation with external dimension system as taught at the prescribed course,
- the calculation taking into account thermal bridges with linear thermal transmittances obtained by numerical calculation with program AnTherm and
- the calculation taking into account thermal bridges with default values of linear thermal transmittances.

It should be noted that that default values obtained by ISO 14683 are calculated for parameters representing worst-case situations, rounded to the nearest 0.05 W/(m·K).

Heat transfer coefficient through ground H_{g} was also calculated, as prescribed by standard ISO 13370 [11].

Finally, in our case transmission heat transfer coefficient H_{T} is obtained as the sum of two coefficients

$$H_{\mathrm{T}} = H_{\mathrm{D}} + H_{\mathrm{g}}. \quad (3)$$

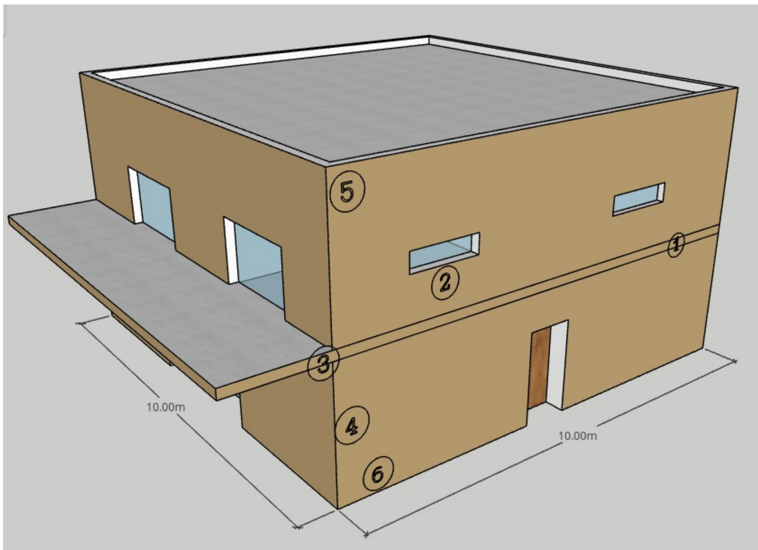

Figure 1. Design of a “typical” family house with two floors and a flat roof used for the calculation. We identified six types of thermal bridges, which are designated by numbers: 1- partition/wall, 2 - window/wall, 3 - balcony, 4 - wall/wall, 5 - roof/wall and 6 - ground floor/wall.

Table 1. The layers of the most important building elements of thermal envelope.

Floor	Wall	Roof
gravel	1,5 mm finishing layer	8 cm screed
10 cm reinf. concrete	adhesive mortar	20 cm XPS
12 cm XPS	20 cm EPS F	20 cm reinf. concrete
7 cm screed	adhesive and spackle mortar	
	38 cm Porotherm bricks	

3. RESULTS

As a simple example, we have designed a “typical” family house with floor plan of dimensions 10 m × 10 m, two floors of height 2.85 m corresponding to ceiling height of 2.5 m and a flat roof, as shown in Figure 1. In order to maximize the effect of thermal bridges, we intentionally designed the house with good thermal insulation, but with the thermal bridges not being well addressed. From our experience, in Slovenia the problems of thermal bridges are generally neglected, so this represents a common situation. All the calculations were done using the external dimensions of the building.

The most important layers of the building elements of thermal envelope are listed in Table 1.

Table 2. Areas and thermal transmittances of building elements of thermal envelope.

Element	$A(\mathrm{m}^2)$	U $(\mathrm{W}/(\mathrm{m}^2\mathrm{K}))$
Wall	200.3	0.126
Roof	95.3	0.162
ground floor	95.3	0.175
Windows	21.6	0.700

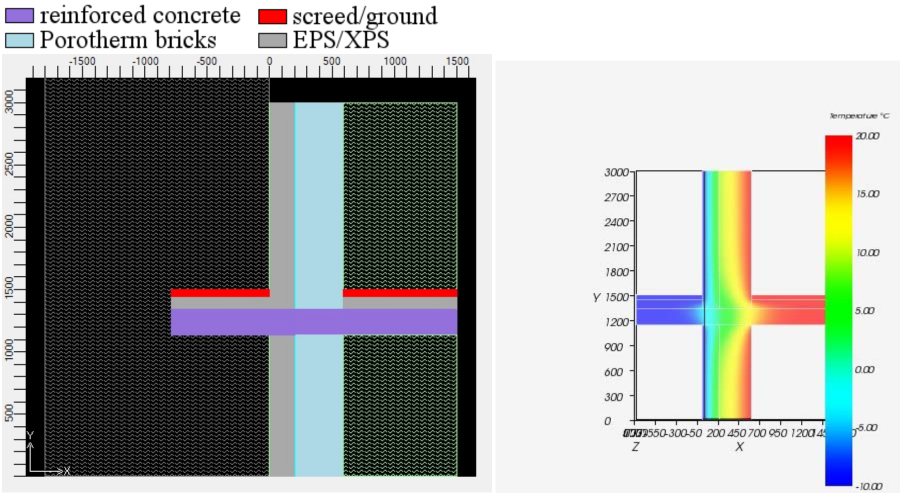

Figure 2. The calculation procedure for the thermal bridge number 3 - balcony. Left side picture shows the thermal bridge design, right side picture shows temperatures obtained by numerical calculation.

The areas and thermal transmittances of building elements of thermal envelope are presented in Table 2.

We have studied six types of thermal bridges, shown in Figure 1 and listed in Table 3. All calculations were made in accordance with ISO 10211 [10] using program AnTherm.

The most problematic thermal bridge, the balcony thermal bridge (number 3), is presented in Figure 2.

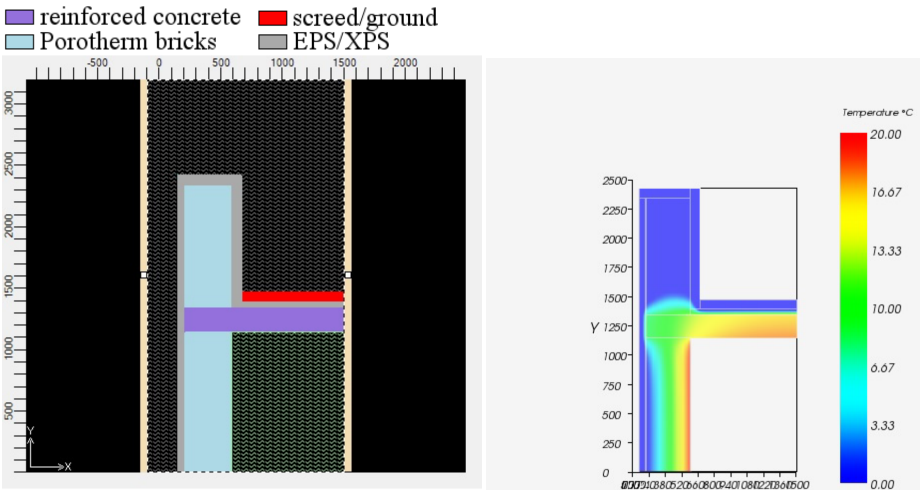

Figure 3. The calculation procedure for the thermal bridge number 5, roof/wall contact. Left side picture shows the thermal bridge design, right side picture shows temperatures obtained by numerical calculation.

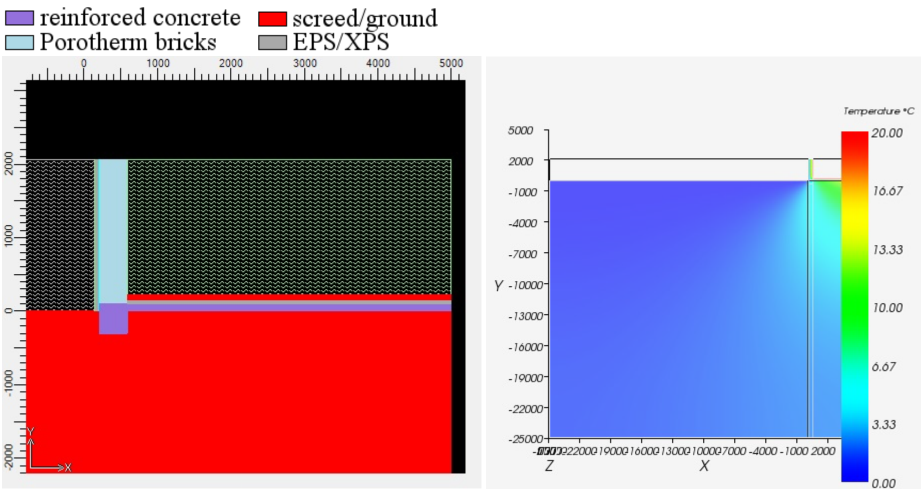

Figure 4. The calculation procedure for the thermal bridge number 6, ground floor/wall contact. Left side picture shows the thermal bridge design, right side picture shows temperatures obtained by numerical calculation.

Other important thermal bridges are the roof/wall contact thermal bridge (number 5), presented in Figure 3, and the ground floor/wall contact thermal bridge (number 6), presented in Figure 4. Note that ISO 10211 requires that temperatures for thermal bridges in contact with the ground are calculated in much wider region.

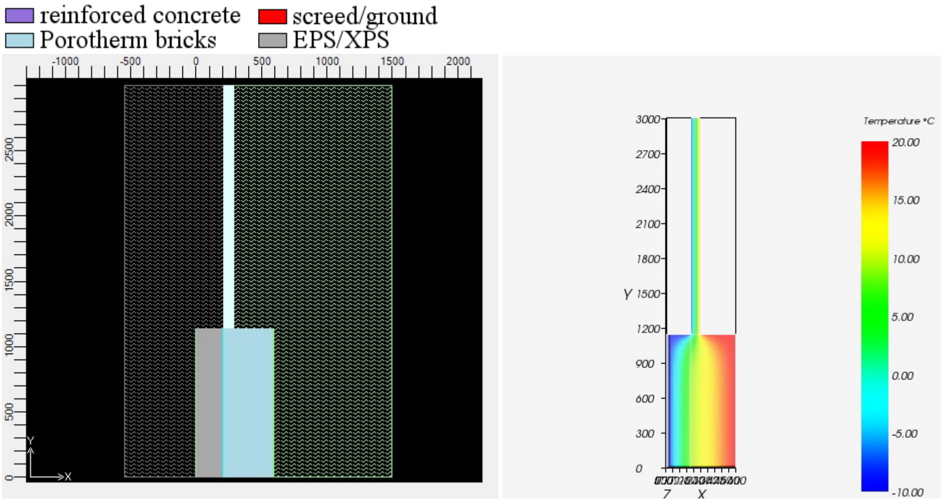

Figure 5. The calculation procedure for the thermal bridge number 2, window/wall contact. Left side picture shows the thermal bridge design, right side picture shows temperatures obtained by numerical calculation.

Table 3. Lengths and linear thermal transmittances of thermal bridges.

Figure 1 notation	Type/Description	l(m)	$\Psi_e(W/(m \cdot K))$ numerical value	ISO 14683 notation	$\Psi_e(W/(m \cdot K))$ default value
1	partition/wall	30.0	0.027	IF1	0.00
2	window/wall	74.6	0.055	W15	0.00
3	balcony	10.0	0.441	B1	0.95
4	wall/wall	22.4	-0.088	C1	-0.05
5	roof/wall	40.0	-0.014	R11	0.05
6	ground floor/wall	40.0	0.247	GF5	0.60

A special procedure was used to determine the approximate linear thermal transmittance of the wall-window contact, as shown in Figure 5. The window frame was simulated by a uniform material, which average thermal conductivity $\bar{\lambda}$ was determined from the equation

$$U_f = \frac{1}{R_{se} + \frac{d}{\bar{\lambda}} + R_{si}}, \qquad (4)$$

where U_f is thermal transmittance of the frame, d is frame thickness and R_{se} and R_{si} are external and internal surface resistances according to ISO 6946 [12], respectively. Note that the design of this as well as the previous thermal bridges is in accordance with the initial assumption that the thermal bridges are not being well addressed.

The results of numerical calculation and default values from ISO 14683 are presented in Table 3.

Table 4. The results for the transmission heat transfer coefficient and the thermal bridges' share.

Calculation type	$H_{\mathrm{T}}(\mathrm{W/K})$	thermal bridges' share
No thermal bridges	75.2	0%
Simplified calculation	100.1	33%
Thermal bridges, numerical values	92.6	23%
Thermal bridges, default values	109.6	46%

The obtained value for the heat transfer coefficient through ground is 16.6 W/K. Finally, the results for the transmission heat transfer coefficient (3) are presented in Table 4.

4. DISCUSSION

First we comment differences between default values from ISO 14683 and values obtained by the numerical calculations. As expected, most default values are larger than numerical values, which is in accordance with the assumption that the former are calculated for parameters representing worst-case situations. Surprisingly, IF1 and W15 default values are 0.00 W/(m·K), despite the fact that according to our numerical calculations they should be at least 0.05 W/(m·K), after rounding to the nearest 0.05 W/(m·K).

The result of the calculation including thermal bridges, with linear thermal transmittances obtained by numerical calculation should be considered the most correct and referent: The transmission heat transfer coefficient is 0.222 W/K, while 25% of all thermal losses are due to the thermal bridges. Note that the similar calculation for the low-energy house case gave 8% share [13]. This is consistent with our results where design choice was meant to maximize effect of thermal bridges.

The simplified calculation returned even higher transmission heat transfer coefficient of 0.241 W/K, which is 9% higher than the referent value. This is obviously due to the fact that correction factor $\Delta U_{\Psi} = 0.06\,\mathrm{W/(m^2K)}$ is independent of the energy efficiency of the house, giving larger thermal bridges' share for better insulated buildings. We conclude that the simplified method, though returning values that are too high, gives good estimate for the worst-case scenario of our study case.

The result of the calculation including thermal bridges with default linear thermal transmittances, gives the highest transmission heat transfer coefficient of 0.264 W/K, which is 19% higher than the referent value. This is understandable, as linear thermal transmittances are calculated for parameters representing worst-case situations. However, default values for most critical situations like balcony and ground floor/wall thermal bridge (Table 3) are twice as high as the exact values and not reliable enough for the calculation.

5. CONCLUSION

In this paper we have compared three methods for calculation of thermal losses of a "typical" family house. The first is the simplified calculation using a correctional factor; The second takes into account the thermal bridges, using linear thermal transmittances obtained by numerical calculation; And the third takes into account the thermal bridges, using default values for linear thermal transmittances.

The second method gives the most exact, referent values. On the other hand, the first method gives values that are too high.

Since the numerical calculation of the linear thermal transmittances is a laborious process, the alternative to the first method would be the third method using default values of linear thermal transmittances. However, our calculations show that for our study case, the third method results are even further away from the referent ones.

We conclude that more precise default values of linear thermal transmittances would be beneficial in order to account for thermal bridges better. Further investigation is underway.

Acknowledgement

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