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DETERMINATION OF LINEAR AND POINT THERMAL TRANSMITTANCE OF THE MOST USUAL THERMAL BRIDGES IN EXTERNAL WALLS

The paper gives the results for calculations of linear and point thermal transmittance of the most usual thermal bridges in external walls. The results are shown for external walls with thermal insulation and rendering and for ventilated curtain walling.

Keywords: linear thermal transmittance, point thermal transmittance, building envelope, thermal resistance, thermal bridges

INTRODUCTION

According to the Ukrainian Norms [1] the main characteristic that determines the insulation parameters of external building components is the thermal resistance. Design value of this parameter should be not less than the regulatory requirements value according to the [1]. At the same time, according to norms, described above, the design calculations of the thermal resistance must take into account the influence of the thermal bridges by the linear and point thermal transmittance. Also, such influence should be taken into account in the calculations of the transmission heat transfer coefficients at the energy efficiency calculations according to the EN ISO 13790 [2]. An analysis of existing methods for calculation of linear and point thermal transmittance showed that their definition is based on the numerical calculation of two-dimensional and three-dimensional temperature field [3]. Currently, designers in the practice are not always able to carry out complex calculations using sophisticated software to determine the temperature fields of external building elements. One solution of the problem is to use the thermal bridge catalogues with default values of linear and point thermal transmittance. However, in Ukrainian standards there is no such information. The examples of thermal bridges, which are given in [1] refer to the old existing buildings and can't be taken for design calculations of new building. Therefore, these problems led to the purpose of this work - to derive the engineering dependencies for the calculation of linear and point thermal transmittance for common thermal bridges in modern external constructions.

1. PRINCIPLE FOR THE CALCULATION OF THE THERMAL RESISTANCE

Thermal resistance of any external building constructions R_{Σ}, in $m^2 \cdot K/W$, according to the [1] is calculated by using the equation:

$$R_{\Sigma} = \frac{A_{\Sigma}}{\sum_{i=1}^{I} \frac{A_i}{R_{T,i}} + \sum_{k=1}^{K} l_k \psi_k + \sum_{j=1}^{J} n_j \chi_j} \tag{1}$$

when:
A_{Σ} - is the total area of construction [m^2];
A_i - is the area of part without thermal bridges i of the construction [m^2];
$R_{T,i}$ - is the total thermal resistance of part without thermal bridges i of the construction [$m^2 \cdot K/W$], calculated accordance to the [4 (formula (4)];
l_k - is the length of linear thermal bridge k [m^2];
ψ_k - is the linear thermal transmittance of linear thermal bridge k [W/(m·K)];
n_j - is the number of the point thermal bridge j;
χ_j - is the point thermal transmittance of the point thermal bridge j [W/K].

As seen from the formula (1) all types of external building constructions, which are thermally irregular (have in their composition thermal bridges), should be calculated with linear and point thermal transmittance coefficients.

The same principle is used in EN 14683 [5] for calculation of the transmission heat transfer coefficients H_D [W/K], where the contribution due to the thermal bridges is included according to the equation:

$$H_D = \sum_{i=1}^{I} A_i U_i + \sum_{k=1}^{K} l_k \psi_k + \sum_{j=1}^{J} \chi_j \tag{2}$$

Thus, the obtained results may also be used in the calculation according to European Norms.

For calculation there were selected the most common thermal bridges in modern external walls, which are the following:

- Intermediate floors;
- Balcony overlaps;
- Corners;
- Window openings;
- Brackets in systems of external walls with a ventilated air gap;
- Anchors for mechanical fixing of the insulation layer;
- Metal coupling elements.

The calculation was made for external walls with thermal insulation and rendering according to the [6] and for external walls with a ventilated air gap. For calculation overall internal dimensions are used. The results are shown in Tables 1 and 2.

Table 1. **Values of the linear thermal transmittance**

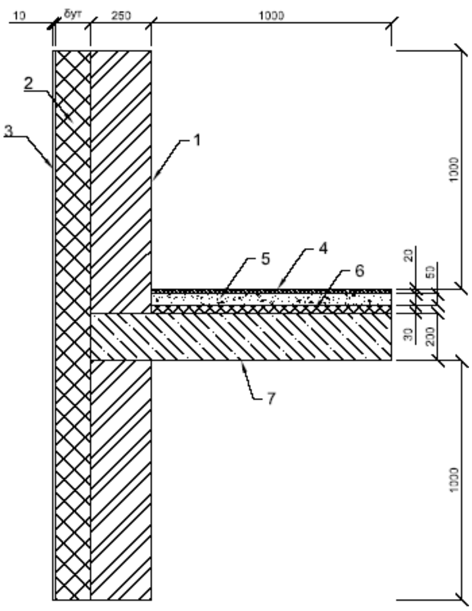
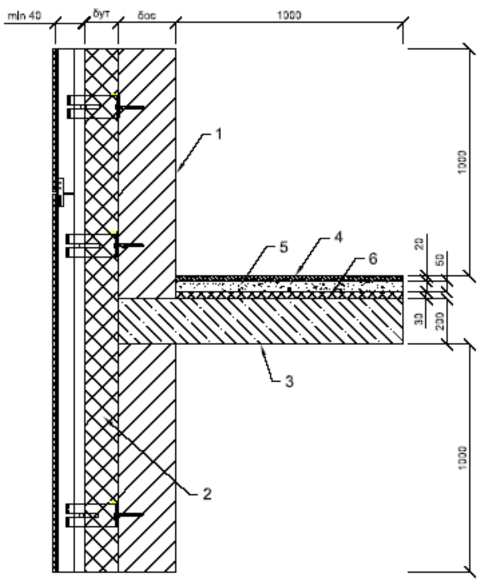
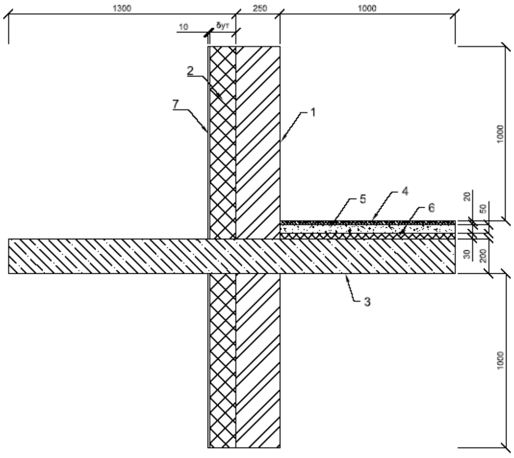
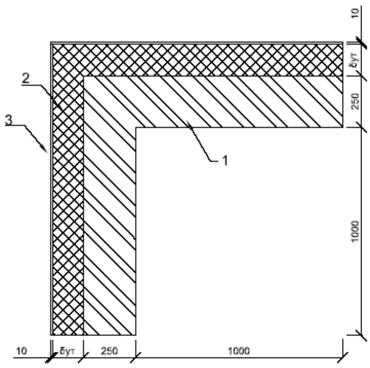
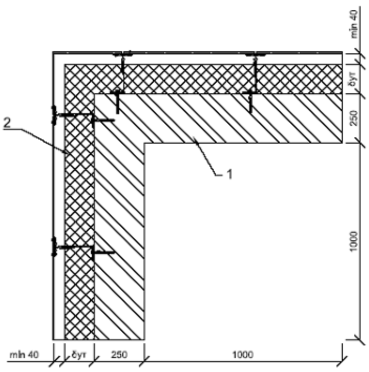
<table>
<tr><th>The scheme of the thermal bridge</th><th colspan="4">Parameters of the insulation layer</th></tr>
<tr><td rowspan="8">Intermediate floor. External walls with thermal insulation and rendering

</td><td rowspan="3">Thermal conductivity λ [W/(m·K)]</td><td colspan="3">Thickness of the insulation material δ</td></tr>
<tr><td>120 mm</td><td>150 mm</td><td>180 mm</td></tr>
<tr><td colspan="3">ψ [W/(m·K)]</td></tr>
<tr><td>0.040</td><td>0.080</td><td>0.073</td><td>0.062</td></tr>
<tr><td>0.045</td><td>0.087</td><td>0.082</td><td>0.069</td></tr>
<tr><td>0.050</td><td>0.094</td><td>0.090</td><td>0.076</td></tr>
<tr><td colspan="4">1 - masonry
2 - thermal insulation
3 - rendering
4 - wooden floor
5 - cement covering
6 - sound-insulating layer
7 - concrete</td></tr>
<tr></tr>
<tr><td rowspan="7">Intermediate floor. External walls with a ventilated air gap

</td><td rowspan="3">Thermal conductivity λ [W/(m·K)]</td><td colspan="3">Thickness of the insulation material δ</td></tr>
<tr><td>150 mm</td><td>200 mm</td><td>250 mm</td></tr>
<tr><td colspan="3">ψ [W/(m·K)]</td></tr>
<tr><td>0.040</td><td>0.074</td><td>0.056</td><td>0.046</td></tr>
<tr><td>0.045</td><td>0.082</td><td>0.063</td><td>0.051</td></tr>
<tr><td>0.050</td><td>0.091</td><td>0.070</td><td>0.056</td></tr>
<tr><td colspan="4">1 - masonry
2 - thermal insulation
3 - concrete
4 - wooden floor
5 - cement covering
6 - sound-insulating layer</td></tr>
</table>

Table 1. (continued)

The scheme of the thermal bridge	Parameters of the insulation layer			
Balcony overlap 	Thermal conductivity λ [W/(m·K)]	Thickness of the insulation material δ		
		120 mm	150 mm	180 mm
		ψ [W/(m·K)]		
	0.040	0.839	0.797	0.758
	0.045	0.833	0.793	0.754
	0.050	0.827	0.789	0.751
	1 - masonry 2 - thermal insulation 3 - concrete 4 - wooden floor 5 - cement covering 6 - sound-insulating layer 7 - rendering			
Corners. External walls with thermal insulation and rendering 	Thermal conductivity λ [W/(m·K)]	Thickness of the insulation material δ		
		120 mm	150 mm	180 mm
		ψ [W/(m·K)]		
	0.040	0.131	0.115	0.103
	0.045	0.142	0.125	0.107
	0.050	0.152	0.135	0.121
	1 - masonry 2 - thermal insulation 3 - rendering			
Corners. External walls with a ventilated air gap 	Thermal conductivity λ [W/(m·K)]	Thickness of the insulation material δ		
		150 mm	200 mm	250 mm
		ψ [W/(m·K)]		
	0.040	0.115	0.096	0.084
	0.045	0.125	0.106	0.092
	0.050	0.135	0.114	0.100
	1 - masonry 2 - thermal insulation			

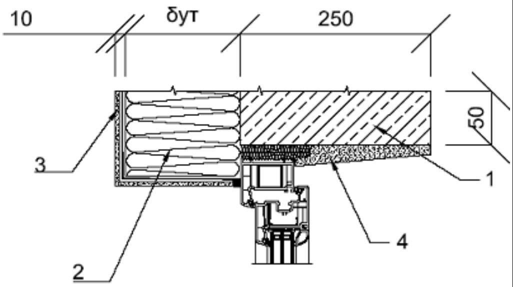
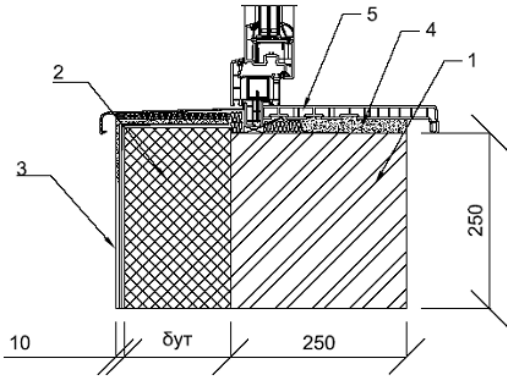
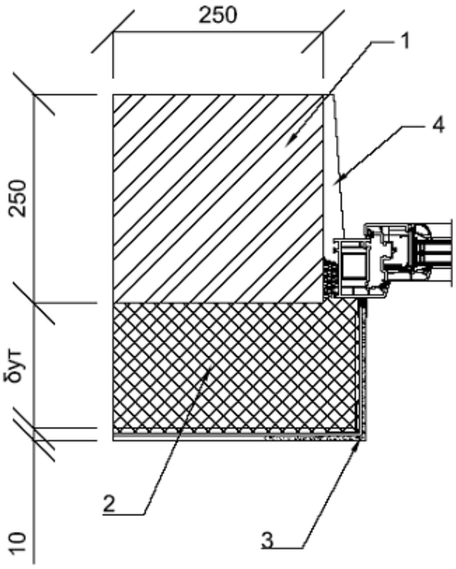
The scheme of the thermal bridge	Parameters of the insulation layer			
Window openings. External walls with thermal insulation and rendering 	Thermal conductivity λ [W/(m·K)]	Thickness of the insulation material δ		
		120 mm	150 mm	180 mm
		ψ [W/(m·K)]		
	0.045±0.005	0.081	0.081	0.080
	1 - concrete 2 - thermal insulation 3 - rendering 4 - cement			
		ψ [W/(m·K)]		
	0.045±0.005	0.059	0.064	0.068
	1 - masonry 2 - thermal insulation 3 - rendering 4 - cement 5 - PVC windowsill			
		ψ [W/(m·K)]		
	0.045±0.005	0.068	0.071	0.073
	1 - concrete 2 - thermal insulation 3 - rendering 4 - cement			

Table 1. (continued)

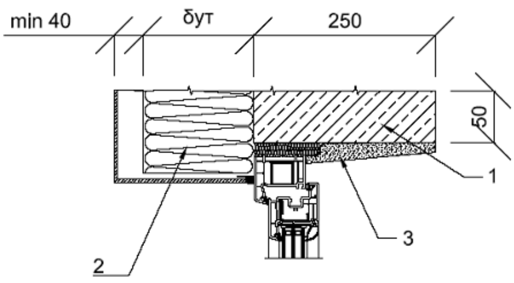
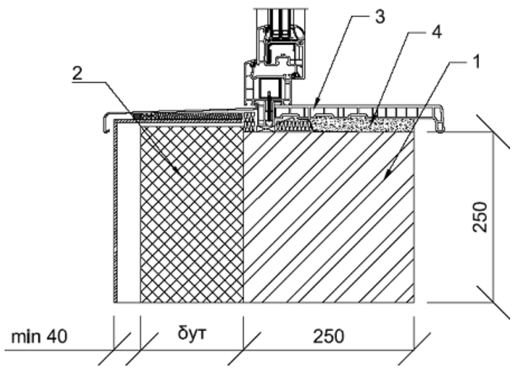
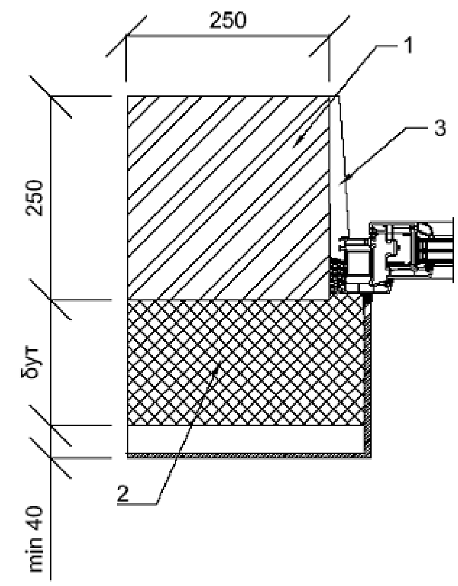
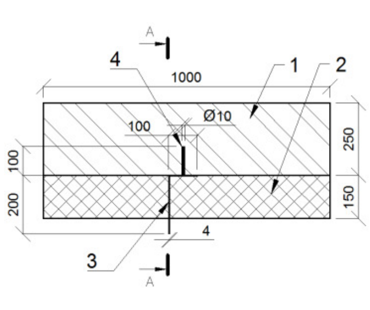
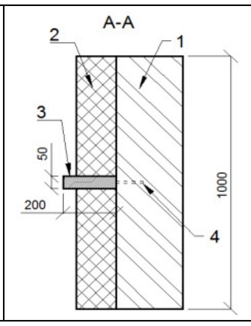
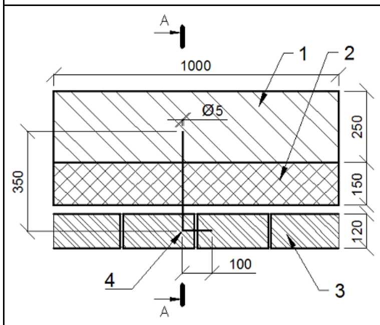
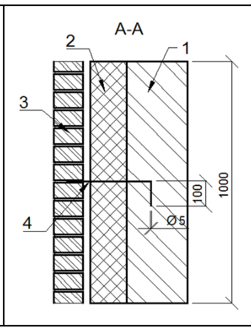
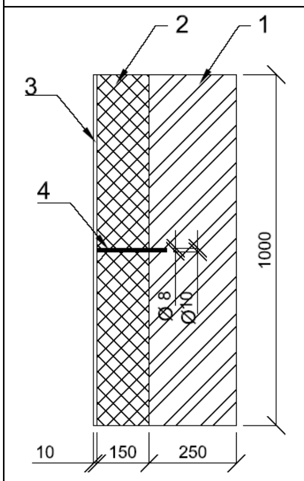
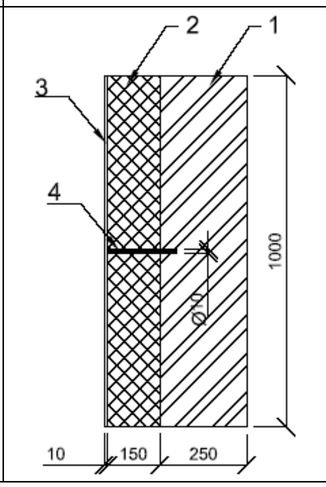
The scheme of the thermal bridge	Parameters of the insulation layer			
Window openings. External walls with a ventilated air gap	Thermal conductivity λ [W/(m·K)]	Thickness of the insulation material δ		
		150 mm	200 mm	250 mm
		ψ [W/(m·K)]		
	0.045±0.005	0.063	0.062	0.062
	1 - concrete 2 - thermal insulation 3 - cement			
		ψ [W/(m·K)]		
	0.045±0.005	0.035	0.041	0.046
	1 - masonry 2 - thermal insulation 3 - PVC windowsill 4 - cement			
		ψ [W/(m·K)]		
	0.045±0.005	0.049	0.053	0.05
	1 - concrete 2 - thermal insulation 3 - cement			

Table 2. **Values of the point thermal transmittance**

The scheme of the thermal bridge		Parameters of the insulation layer	
Bracket in systems of external walls with a ventilated air gap		Thermal conductivity λ [W/(m·K)]	Thickness of the insulation material δ
			150 mm
			χ [W/K]
		0.045	0.015
		1 - masonry 2 - thermal insulation 3 - bracket of galvanized steel 4 - metal anchor	
Z-likeness metal coupling element in systems of external walls with a ventilated air gap and facing brick masonry			150 mm
			χ [W/K]
		0.045	0.018
		1 - masonry 2 - thermal insulation 3 - facing brick masonry 4 - Z-likeness metal coupling element	
External walls with thermal insulation and rendering			150 mm
a) anchors with a galvanized steel screw	b) anchors with a plastic screw		χ [W/K]
		0.045	a) 0.005 b) 0.0015
		1 - masonry 2 - thermal insulation 3 - rendering 4a - anchors with a galvanized steel screw 4b - anchors with a plastic screw	

CONCLUSION

The values of linear and point thermal transmittance, which are given in the article, will allow designers to carry out correct calculations of thermal resistance of external building components with thermal bridges. At the same time, these data formed the basis of relevant applications of the pr. ДСТУ Б В.2.6-189:2013 "Methods for choosing of insulation material for insulation of buildings" (The State Standard of Ukraine). This standard is aimed to develop and improve the DBN [1] concerning the choosing of insulation material and estimation of thermal resistance.

REFERENCES

[1] ДБН В.2.6-31:2006, Constructions of buildings and structures - Thermal insulation of buildings, Kyiv 2006 (The State Ukrainian Norms).
[2] EN ISO 13790, Energy performance of buildings - Calculation of energy use for space heating and cooling.
[3] ISO 10211, Thermal bridges in building constructions - Heat flows and surface temperatures - Detailed calculations.
[4] EN ISO 6946, Building components and building elements - Thermal resistance and thermal transmittance - Calculation method.
[5] EN 14683, Thermal bridges in building constructions - Linear thermal transmittance - Simplifed methods and default values.
[6] ETAG 004, External thermal insulation composite systems (ETICS) with rendering.

WYZNACZENIE LINIOWYCH I PUNKTOWYCH WSPÓŁCZYNNIKÓW PRZENIKANIA CIEPŁA DLA NAJCZĘŚCIEJ WYSTĘPUJĄCYCH MOSTKÓW CIEPLNYCH W ŚCIANACH ZEWNĘTRZNYCH

W artykule przedstawiono wyniki obliczeń dotyczące wyznaczenia wartości liniowych i punktowych współczynników przenikania ciepła dla mostków cieplnych zlokalizowanych w ścianach zewnętrznych. Przedstawiono wyniki dla ścian zewnętrznych z izolacją cieplną oraz okładziną i dobrze wentylowaną warstwą powietrza.

Słowa kluczowe: **liniowy współczynnik przenikania ciepła, punktowy współczynnik przenikania ciepła, okrywa budynku, opór cieplny, mostki cieplne**