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CONTRIBUTION TO ANALYSIS OF ENERGY EFFICIENCY OF SMALL SPORTS FACILITIES

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*Abstract***.** Contemporary architectonic concept and construction of sport facilities in general is characterized by the principle of energy efficient building. Therefore, the energy efficiency in buildings-sport facilities becomes one of the key problems of the present architecture. This paper will discuss and display the evaluation of energy efficiency of three buildings-sports facilities in terms of influence of the value of transparent surface, primarily with the goal of analysis of their energy efficiency (total thermal losses). The presented examples, displayed one suppositional buildings-sport facilities, on which three of the various sizes of the transparent thermal envelope according to the current regulations, The Building Energy Efficiency Regulation – Official Gazette of the Republic of Serbia, 061/2011, will be analyzed.

Key words: thermal envelope, transparent surfaces, transmission losses

General data of the presented examples

The analyzed building-small sports facilities is designed in form of a «shoe box» with dimensions (L×W×H) 30×20×10 m. The displayed analysis includes study of three cases of the different value of glazed parts of the façade (transparent surface) in relations to the total thermal envelope. To be able to make a comparison to the conditions of assumptions, we will define in accordance with their prescribed maximum values – U_{max} W/(m^2K). Structures of building elements used in the analysis are: Exterior walls type SZ-U_{max}=0,30 W/(m^2K); Flat roof type RK-U_{max}=0,15 W/(m^2K); The floor on the ground type PT-U_{max}=0,30 W/(m^2K). Glazed-transparent parts of the façade (façade windows) type SW are analyzed by new improved coefficients of thermal conductivity U_{max}=1,50 W/(m^2K). Calculation of total thermal losses was provided for three cases of the total area of transparent part of the

façade envelope (Ex.1 – cca30 %; Ex.2 – cca60 % and Ex.3 – cca90 % of total façade area).

Table 1.1

General and input data for the calculation – Total transmission losses

Design temperature of the outside air (Niš) θ_e [^oC]	-14,5^oC		
Design temperature of the intside air θ_i [^oC]	+20,0^oC		
Surface of building thermal envelope A_f [m²]	2.200,00 m²		
Heated volume of the building V_e [m³]	6.000,00 m³		
Building shape factor fo=A_f/V_e [m^{-1}]	0,3666 m^{-1}		
Share of transparent surfaces (Ex-1; Ex-2;Ex-3) [%]	0,136	0,273	0,409
Airtight of windows	middle		
The number of air changes n [h^{-1}]	0,6		

Calculation of heat losses – example 1

Transmission heat losses – example 1 - HT [W/K]

Surface transmission losses HTS [W/K]

Table 1.2

Preview of surface transmission losses – nontransparent surfaces (Ex-1)

Description of the building elements	Label	max U (W/m^2K)	U (W/m^2K)	A (m^2)	Fx	U×A×Fx
External walls	SZ	0,30	0,30	700,00	1.0	210,00
The flat roof	RK	0,15	0,15	600,00	1.0	90,00
Floor on the ground	PT	0,30	0,30	600,00	0.5	90,00
Total				1.900,00		390,00

Table 1.3

Preview of surface transmission losses – transparent surfaces (Ex-1)

Windows	SW	1,50	1,50	300,00	1.0	450,00
Total				300,00		450,00
Σ A				2.200,00		
Total surface transmission losses - Σ H_{TS} (W/K)					H_{TS}=840,00	

Linear transmission losses HTB [W/K]

H_{TB}=0.1×ΣA=0.1×2.200,00=220,00	H_{TB}=220,00 W/K

Total transmission losses HT [W/K]

$H_T=H_{TS}+H_{TB}$=840,00+220,00=940,00	H_T=1.060,00W/K

Ventilating thermal losses of the building Hv [W/K]

$H_V=0.33\times V_e\times n=0.33$ Wh/m^{3}K$\times$6.000,00 m$^3\times$0,6 h^{-1}	$H_V=1.188,00$ W/K

The total thermal losses – example 1

Table 1.4

Preview of total heat loss – example 1

Data on heat losses	[kW]
Transmission losses through the not transparent part of the build. envelope	13,45
Transmission losses through windows and doors	15,52
Ventilation losses through windows and doors	40,97
The total thermal losses – example 1	69,94

Calculation of heat losses – example 2

Transmission heat losses – example 2 – HT [W/K]

Surface transmission losses HTS [W/K]

Table 1.5

Preview of surface transmission losses – nontransparent surfaces (Ex-2)

Description of the building elements	La-bel	max U (W/m^{2}K)	U (W/m^{2}K)	A (m^2)	Fx	U×A×Fx
External walls	SZ	0,30	0,30	400,00	1.0	120,00
The flat roof	RK	0,15	0,15	600,00	1.0	90,00
Floor on the ground	PT	0,30	0,30	600,00	0.5	90,00
Total				1.800,00		300,00

Table 1.6

Preview of surface transmission losses – transparent surfaces (Ex-2)

Windows	SW	1,50	1,50	600,00	1.0	900,00
Total				600,00		900,00
Σ A				2.200,00		
Total surface transmission losses - Σ H_{TS} (W/K)					$H_{TS}=1.200,00$	

Linear transmission losses HTB [W/K]

$H_{TB}=0.1\times\Sigma A=0.1\times2.200,00=220,00$	$H_{TB}=220,00$ W/K

Total transmission losses HT [W/K]

$H_T=H_{TS}+H_{TB}=1.200,00+220,00=1.030,00$	$H_T=1.440,00$W/K

Ventilating thermal losses of the building Hv [W/K]

$H_V=0.33\times V_e\times n=0.33$ Wh/m^{3}K$\times$6.000,00 m$^3\times$0,6 h^{-1}	H_V=1.188,00 W/K

The total thermal losses – example 2

Table 1.7

Preview of total heat loss – example 2

Data on heat losses	[kW]
Transmission losses through the not transparent part of the build. envelope	10,35
Transmission losses through windows and doors	31,05
Ventilation losses through windows and doors	40,97
The total thermal losses – example 1	82,37

Calculation of heat losses – example 3

Transmission heat losses – example 3 – HT [W/K]

Surface transmission losses HTS [W/K]

Table 1.8

Preview of surface transmission losses – nontransparent surfaces (Ex-3)

Description of the building elements	Label	max U (W/m^{2}K)	U (W/m^{2}K)	A (m^2)	Fx	U×A×Fx
External walls	SZ	0,30	0,30	100,00	1.0	30,00
The flat roof	RK	0,15	0,15	600,00	1.0	90,00
Floor on the ground	PT	0,30	0,30	600,00	0.5	90,00
Total				1.300,00		210,00

Table 1.9

Preview of surface transmission losses – transparent surfaces (Ex-3)

Windows	SW	1,50	1,50	900,00	1.0	1.350,00
Total				900,00		1.350,00
Σ A				2.200,00		
Total surface transmission losses - Σ H_{TS} (W/K)					H_{TS}=1.560,00	

Linear transmission losses HTB [W/K]

$H_{TB}=0.1\times\Sigma A=0.1\times$2.200,00=220,00	H_{TB}=220,00 W/K

Total transmission losses HT [W/K]

$H_T=H_{TS}+H_{TB}$=1.560,00+220,00=1.030,00	H_T=1.780,00W/K

Ventilating thermal losses of the building Hv [W/K]

$H_V=0.33\times V_e\times n$=0.33 Wh/m^{3}K×6.000,00 m³×0,6 h^{-1}	H_V=1.188,00 W/K

The total thermal losses – example 3

Table 1.10

Preview of total heat loss – example 3

Data on heat losses	[kW]
Transmission losses through the not transparent part of the build. envelope	7,24
Transmission losses through windows and doors	46,57
Ventilation losses through windows and doors	40,97
The total thermal losses – example 1	94,78

Conclusions

Total heat losses, of the analyzed examples of the building-small sports facilities are calculated to the three conditions of the façade (Ex-1; Ex-2; Ex-3). For each of them was calculated the total thermal losses. If we determinate the example-1 as a initial status, the calculation indicates that the total thermal losses in the first case increase to the value for around 17–18 % (for the increase of transparent façade surfaces for 100% in relation to the initial, or 60 % in relation to the total façade area). In the second case the total thermal losses increase to the value for around 35–36 % (for the increase of transparent façade surfaces for 200 % in relation to the initial, or 90 % in relation to the total façade area).

For each of the examples the presented results of the conducted calculations indicate clear non-linearity of calculated parameters, which indicates justification and need of optimization in designing of transparent thermal envelope of buildings.

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