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ANALYSIS OF SOLUTIONS OF LIGHTWEIGHT CASING MADE FROM SANDWICH PANELS IN THE ASPECT OF THERMAL INSULATION

ANALIZA ROZWIĄZAŃ LEKKIEJ OBUDOWY Z PŁYT WARSTWOWYCH W ASPEKCIE IZOLACYJNOŚCI TERMICZNEJ

Abstract

The paper relates to the issue of improving the thermal insulation of external walls of industrial buildings using a lightweight curtain wall with a folded metal sheet filled with mineral wool.

Keywords: *linear thermal bridge*, *thermal insulation*, *lightweight casing*

Streszczenie

W artykule przedstawiono problematykę poprawy izolacyjności cieplnej ścian zewnętrznych budynków przemysłowych wykonanych z blachy fałdowej z wypełnieniem z wełny mineralnej.

Słowa kluczowe: *liniowy mostek cieplny*, *izolacyjność termiczna*, *lekka obudowa*

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1. Introduction

The thermal insulation of external walls made in the form of wall panels partially depends on the method of connection between them and the method of attachment to the metal structural elements. The method of wall panels connection has two main consequences:

1) it effects the casing tightness,
2) it significantly effects the value of the linear *U*-value.

The paper presents the possibility of improving the thermal protection state of wall claddings by changing the method of connecting the casing's metal surface with the metal structural element – load-bearing bolt. Measurements were performed of the two-dimensional heat flow for the selected example of the connection and mounting of sandwich panels in a social-heated part of a warehouse.

2. Research subject

The sandwich panel used as the subject of this investigation has the following specifications:

– profiled sheet $d = 0.088$ cm/internal,
– rock wool $d = 15.0$ cm; $\lambda = 0.037$ W/mK,
– T35 trapezium sheet $d = 0.07$; $\lambda = 50$ W/mK /external,
– vapor and windproof foils (omitted in the calculations),
– profiles of (wall bolts) omega type spaced every 60 cm; $d = 0.01$ cm; $\lambda = 50$ W/mK.

The system of layers and mounting of the analyzed sandwich panel is presented in the figure below, alongside is the thermograph of a warehouse fragment with a built-in wall panel [1].

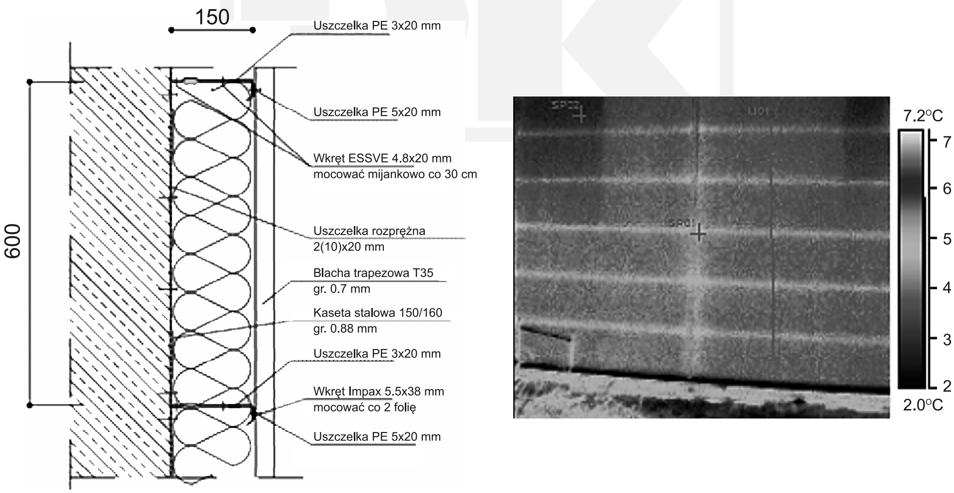

Fig. 1. Layout of the wall sandwich panel layers with mineral wool filling, on the right thermograph of the wall with a sandwich panel

3. Scope and boundary conditions of the analysis

For the tested external walls, the following measurements were performed: the total thermal resistance of the partition; temperature distribution; heat flux density; linear thermal transmittance ψ. Measurements were performed using the Therm 7.1.19 software, based on the use of MES for calculations of any two-dimensional construction element model. The results are shown in graphical form – temperature distribution in the cross-section, the distribution of the heat flux and the results of numerical calculations. Boundary conditions adopted for the calculations: calculation temperatures – as for the climate zone III t_e = –20°C. For the internal environment, normal operating conditions were adopted t_i = +20°C, film coefficient h_e = 25.0 W/(m^{2}K); h_i = 7.69 W/(m^{2}K). For calculations, surface emissivity was adopted – as for the light color, i.e. ε = 0.86 [2].

4. Partition models adopted for measurements

A geometric model of the wall's connection was constructed on the basis of the manufacturer's specifications. The program allows the obtaining of temperature values at any point of the wall's cross section, the total heat flux and thermal transmittance U (W/m^{2}K), and for the conditions of one and two-dimensional heat flow. The model was created in accordance with the guidelines contained in [3]. The actual length of the model adopted for calculations is L = 1.00 m.

For numerical analysis, two models were adopted:
1) the output model (Fig. 1),
2) the modified model.

The modification of the output model involves making a connection in a security panel over the entire length of the panel's connection in the form of additional strip of mineral wool with a width of 15.0 cm. Both computational models are shown in Fig. 2.

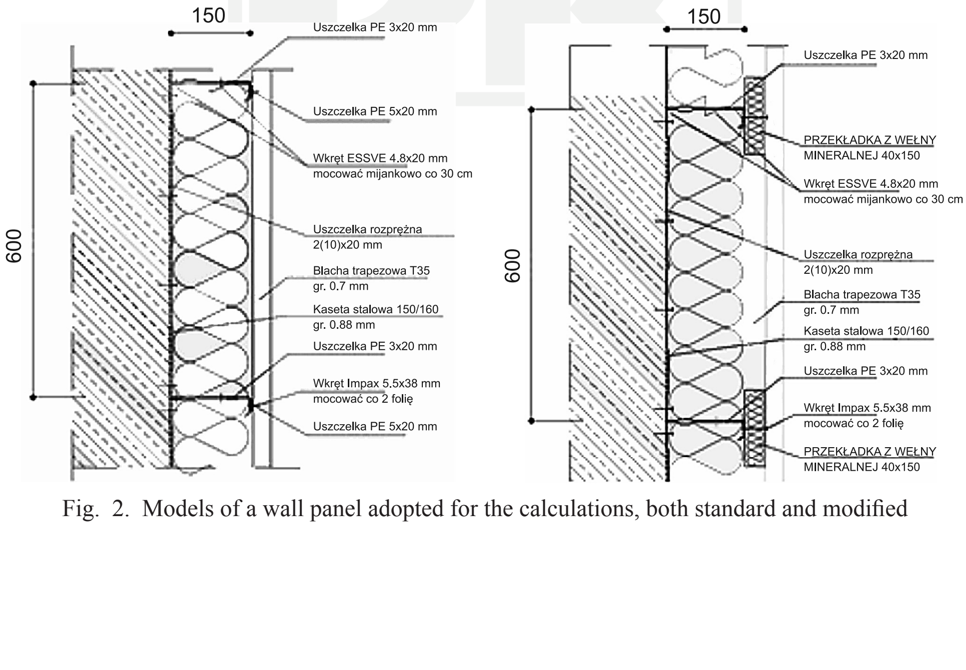

Fig. 2. Models of a wall panel adopted for the calculations, both standard and modified

5. Analysis results

The calculation results are shown in graphical form and summarized in Table 1. The results in both tested models include:
- temperature field distribution,
- heat flux density distribution,
- *U*-value.

Fig. 3. Calculation results of a wall panel – temperature field distribution in wall's cross-section, standard (left) modified (right)

Fig. 4. Calculation results of a wall panel – heat flux density distribution in wall's cross-section, standard (left) modified (right)

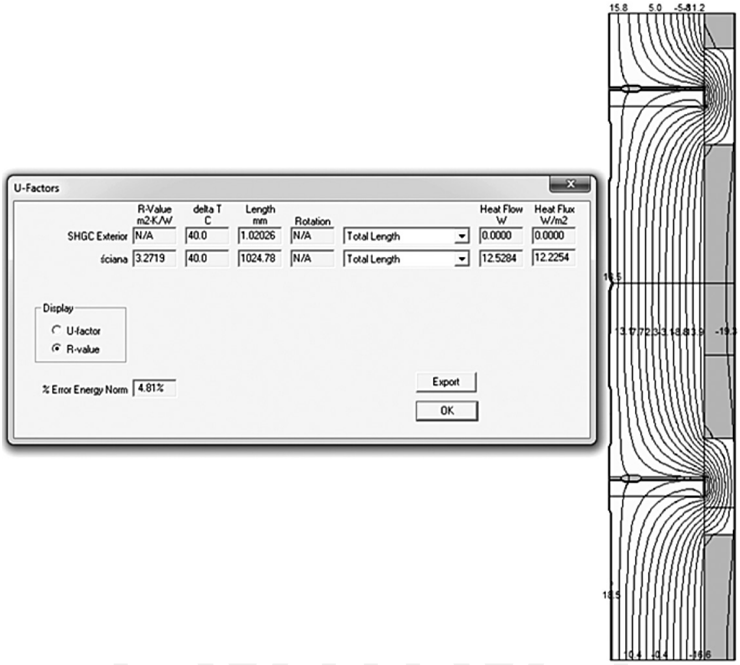

Fig. 5. Exemplary result of the *U*-value calculation. Modified model

In addition, the calculated results of the heat loss are included in the form of the heat flow and heat flux density.

Table 1

Summary of the calculated results

	Thermal transmittance U [W/(m^{2}K)]	Value of linear thermal bridge ψ [W/m]	L – model's linear value [m]	Heat flux [W]	Heat flux density [W/m^2]
Standard model	0.454	0.006	1.00	20.02	20.02
Modified model	0.308	0.002	1.00	12.55	12.35

6. Conclusions

The improvement of the thermal insulation of a building wall is usually associated with housing construction and the construction process understood as thermal modernization. The tightening of rules relating to the thermal protection of building walls applies equally to residential and industrial construction. The reduction of heat loss through external walls is not only due to the increase of the material thickness to thermal insulation. As shown in the analyzed example, equally good results can be gained through the inclusion of additional partial protection of the fragments that are most vulnerable to heat loss. Such elements in the sandwich walls of wall panels type, are panels connections between them and structural elements, load-bearing steel bolts. Using the appropriate thermal pads, *U*-value for the wall panel (caskets) was reduced by more than 35%. On the basis of simple calculations, i.e. the calculation of SPBT rate, it can be proved that such action is economically justified. For the analyzed case, SPBT < 0.8 per year.

References

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[2] Branson A.M., *Infrared: A Handbook for Applications*, Plenum Press, 1966.

[3] EN ISO 10211: 2008 Thermal bridges in building constructions – Calculations of heat flows and surface temperatures-Detailed calculations.