10.2478/v10160-010-0007-2

Transactions of the VŠB – Technical University of Ostrava

No.1, 2010, Vol.X, Civil Engineering Series

paper #7

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ASSESSMENT OF ENVELOPE OF GOS PANEL SYSTEM MEASURED BY THERMOCAMERA

POSOUZENÍ OBVODOVÉHO PLÁŠTĚ PANELOVÉ SOUSTAVY GOS TERMOVIZNÍM MĚŘENÍM

Abstract

A thermocamera can be used for the assessment of building envelopes. Thermal bridges and their seriousness can be detected by a thermocamera. We used these measurements for the detection of thermal bridges and then for the assessment of improving steps on the building envelope. We used these measurements to compare envelopes of two objects of the same panel system which have been revitalized in different ways.

Key words

Thermocamera, envelope, thermal bridge, panel system, assessment.

Abstrakt

Termovizní kamera může být využitá k posuzovaní obvodových plášťů budov. Tepelné mosty a jejich závažnost může být odhalena termokamerou. Využili jsme tato měření pro porovnání obvodového pláště dvou objektů stejné panelové soustavy, které byly rozdílným způsobem revitalizované.

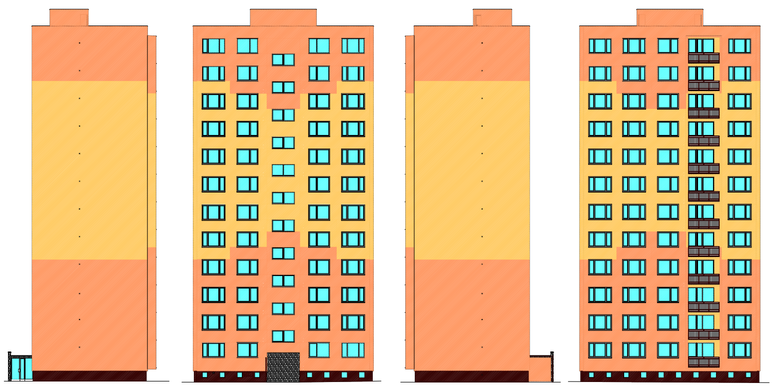

Fig.1: An example of architectural design (insulated object GOS)

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Klíčová slova

Termovizní kamera, obálka budovy, tepelný most, panelová soustava, posouzení.

1 INTRODUCTION

The thermocamera measurement can be considered a modern way of check-up of building envelopes and detection of possible weak parts – thermal bridges. Nowadays, the thermocamera measurement becomes a standard and enabled us to assess the effectiveness of the construction measures carried out in two GOS-66 objects in Ostrava – Zábřeh.

2 DESCRIPTION OF THE OBJECT

The construction panel system GOS, which has been developed for the building panel construction in an undermined area, was based on the construction panel system G57. The block of flats in this construction panel system were realized between 1964 – 1972, predominantly in Northern Moravia (Ostrava, Bohumín, Frýdek – Místek, Havířov, Karviná). The construction panel system GOS was built in versions GOS–64, GOS–66 a GOS–„Bichler“.

The assessed block of flats realized in the construction panel system GOS–66 in Svornosti Street No. 55 and 57 in Ostrava – Zábřeh were realized in 1968.

They are two detached, not through blocks of flats with 1 underground and 12 overground floors with 36 housing units in one construction object. On the ground floor, there are cellar boxes, housing equipment and joining network nodes. On the 1st - 12th floor there are two housing units (Fig. 2).

Both faces of the block of flats of the construction panel system GOS–66 are created by longitudinal spandrel stripes and windows with inter-windows insulating spacers which have been masoned from YTONG. The eastern face of the building is completed by forward loggias. The gables are smooth. A staircase and a passenger lift serve to the vertical transportation.The lift machine room is located on the roof of the block of flats. The forward entrance forming the inner doors is from the west side.

3 DESCRIPTION OF THE ENGINEERING CONSTRUCTION

The construction panel system GOS–66 is a wall panel cross bearing system in modul 3.6 m and with floor construction height of 2.85 m. The building envelope of the block of flats is formed by slag pumice concrete (thickness of 300 mm) in gables and stairs and by gas silicate spandrel stripes (thickness of 250 mm) with double-sided plaster surface finish in faces of the building.

Inside bearing walls are made of reinforced concrete (thickness of 200 mm). The bars are made of reinforced and slag pumice concrete (thickness of 80 mm).

Ceilings are formed by reinfoirced concrete panels (thickness of 120 mm) which contain drawbars to prevent the pulls which can be caused by the undermined area.

The roof construction is designed as a single-layer non-trafficable flat roof which is sloped towards the inner roof inlet. The roof strata consists of a bearing layer which is formed by reinforced concrete ceiling panels (thickness of 120 mm). The slope of the roof flat is achieved by the cindery embankment on the slope on which the thermal insulation of gas silicate plates (thickness of 150 mm) is laid. They are covered with the hydroinsulation strata of two layers IPA 500 SH, followed by Bitagit and by a modified stripe.

Floors in flats above the basement were made on ceiling reinforced concrete (thickness of 120 mm) parts which are covered with the thermal insulation Fibrex (thickness of 15 mm), cardboard A 400H, cement finish and a treading layer made of parquets (event. PVC).

10.2478/v10160-010-0007-2

The original openings in flats were filled with double wooden windows, French windows and inter-windows insulating spacers. In the entrance from the inner doors to the stairs, there was a simple metal wall with the door without an interrupted thermal bridge with a single glass. In the area of the stairs, there were simple metal windows with a single glass without an interrupted thermal bridge. In the basement, there were simple metal windows with wired glass without an interrupted thermal bridge.

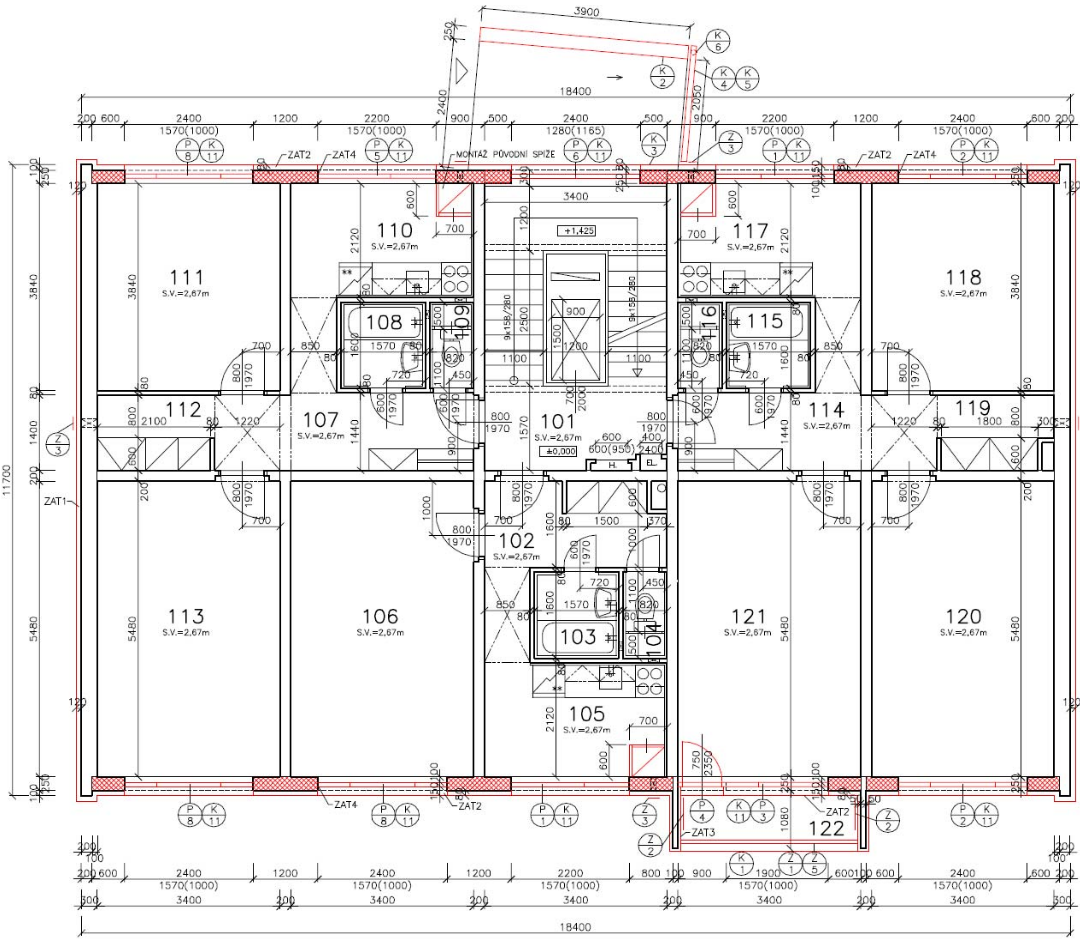


Fig. 2: Layout of the 1st floor (insulated object GOS)

4 DESCRIPTION OF THE CONSTRUCTION WORK

The construction work of the measured object No. 55 concerned the dismantling of window insets due to the replacement of double wooden windows with new plastic windows with a double glazing unit which have $U = 1{,}3$ (W.m^{-2}.K^{-1}).

It was necessary to mason the space of the original window insets with specific blocks Ytong P2-500 on a thin-layer mortar. The brick linings between the windows were anchored into angles. One arm of the agle was attached to the panel face by plugs and the other arm, which was perforated with mortar to achieve better consistency, lay in the bed joint of the brick linings between the windows. For anchoring of every brick lining between the windows two angles were needed. The joint between the brick lining and the head had to be filled with elastic material to prevent dilatation movements.

The construction work of the other measured object No. 57 were based on the extension of the above mentioned construction work in the following way. The replacement of the original windows with plastic ones took place in the basement. The entrance door which was suppossed to be replaced with a plastic one was replaced with a door in a tubular aluminum frame because the plastic entrance door didn‘t prove good in the near surroundings.

Other construction work of the block of flats No. 57 involved the insulation of the building envelope up to the height of 22.5 m with the facade heat insulator EPS 70 from the co MPany Rigips and heat mineral insulation ROCKWOOL FASROCK above this height level. For gables, the thickness of 120 mm was designed, for the face of the building the thickness of 80 mm, and for the insulation of bearing walls and loggia ceilings the thickness of 40 mm (Fig.3). The insulation of the lining and head of the openings was carried out by a contact system (thickness of 20 mm). The flat non-trafficable roof was adjusted. A 150 mm-thick EPS heat insulation layer on which a modified asphalt stripe was applied was added to the existing roof deck.

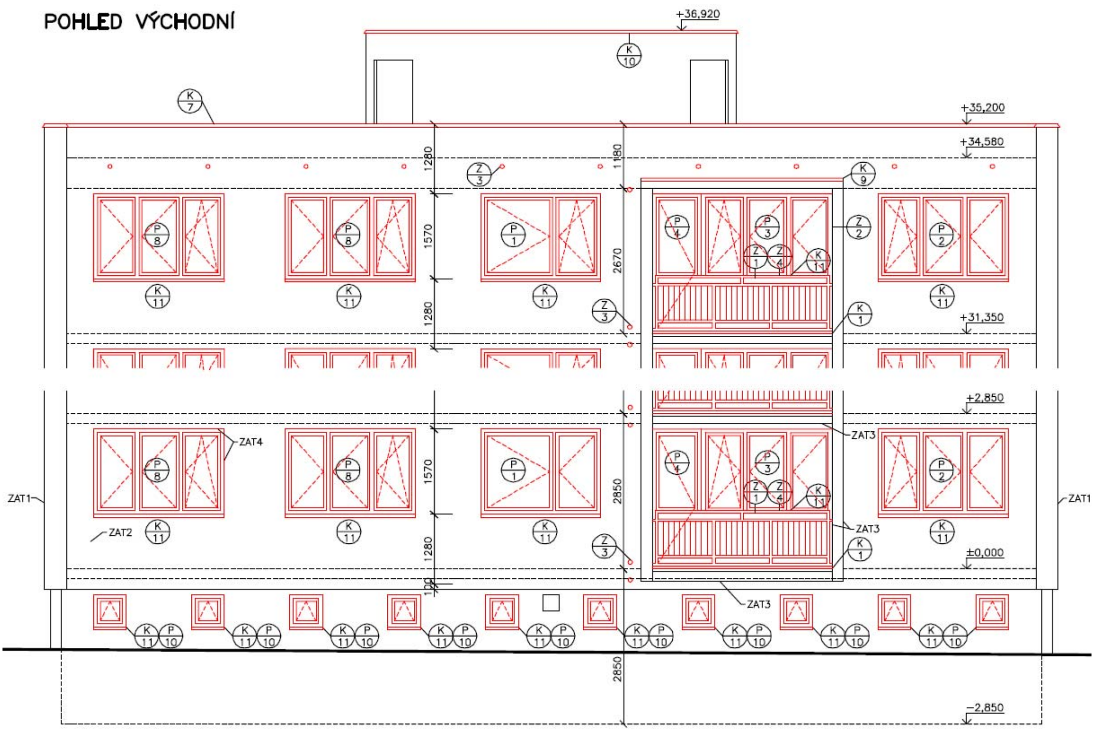


Fig. 3: East view – face of building (insulated object GOS)

In the interior, the insulation by mineral insulation plates ROCKWOOL FASROCK (thickness 40 mm) included only the basement lower ceiling, and only some parts below the flats. The construction work included also the main entrance to the block of flats. The existing openings filling of the were pulled down which was followed by the masoning of the part of the external wall using specific blocks YTONG on a thin-layer. After pulling down of the main entrance the north part of the entrance was replaced with a bar RIGIPS on the metal construction.

10.2478/v10160-010-0007-2

5 DESCRIPTION OF THE MEASUREMENT

The measurements by thermocamera were carried out simultaneously and under the same conditions in the two above described blocks of flats of the construction panel system GOS–66 in Svornosti Street.

Panel objects are generally regarded as problematic in connection to the mould occurrence on the inside surfaces of the cladding. This results from not only users‘ behaviour, but also from faults of the construction itself which are caused especially by the use of components of higher volume weight and thus higher thermal conductivity (e.g. slag pumice concrete).

When modelling and measuring we focused on the detail of the joint of two peripheral walling panels, concerning the vertical joint of a slag pumice concrete gable panel and a gas silicate spandrel panel in the face of building (Fig.4). In the case of an adjusted object, we focused on the part of the cladding which was insulated by mineral wool.

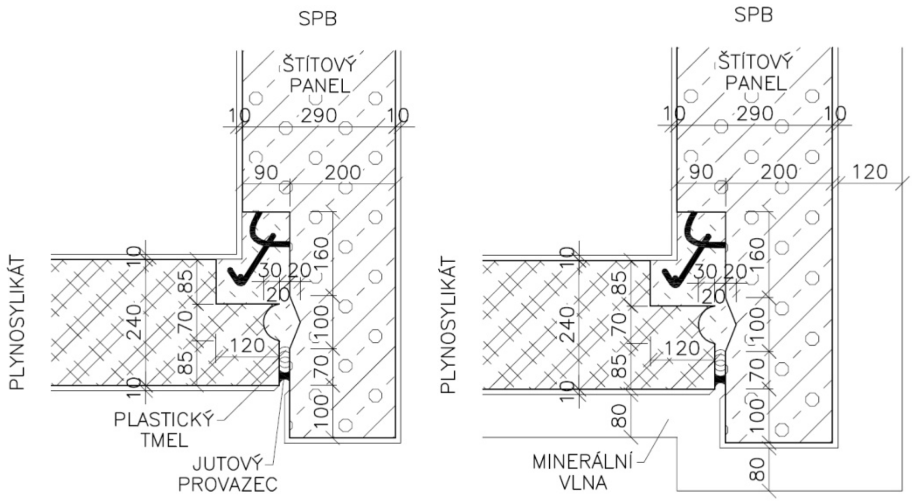


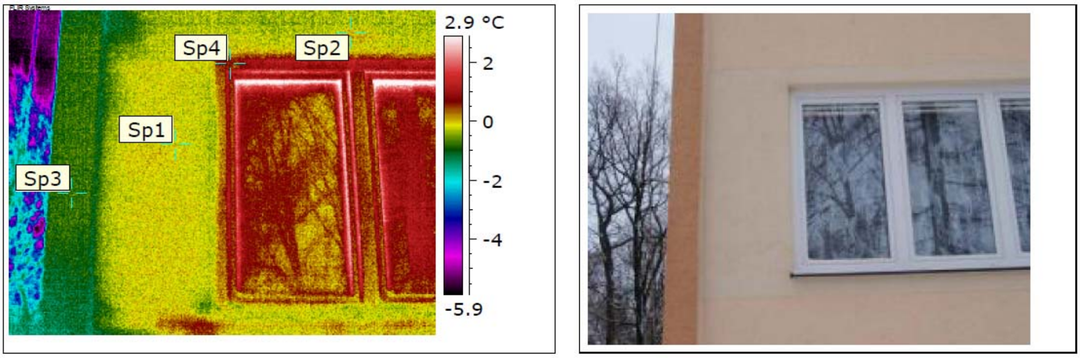
Fig. 4: Detail of a sectional plan of the original and insulated joint of peripheral walling panels

The measurement by thermocamera was carried out on 3rd February 2010 in the morning between 8 and 9 o’clock. The sky was overcast. The outside temperature was –2°C and the relative outside air humidity was 80 per cent.

The temeperature of the inside air in the flats where the measurements were carried out was between +21 and +23°C and the relative inside air humidity was approximately 50 per cent.

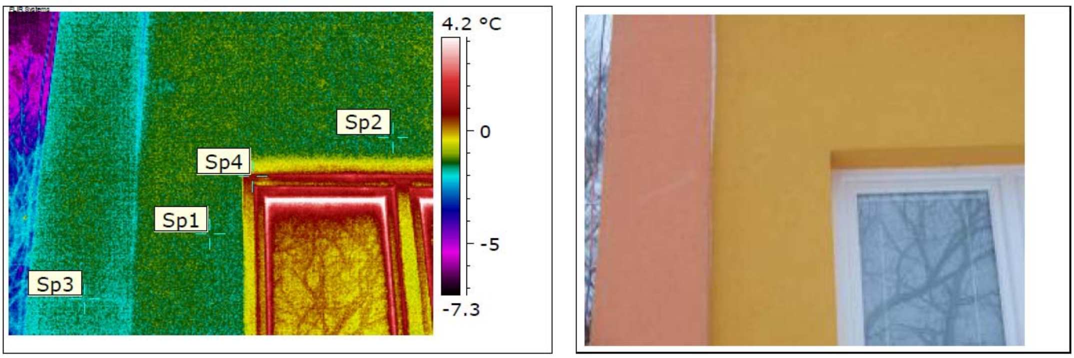
4 MEASUREMENT OUTPUTS

Pictures 5 and 6 demonstrate the surface temperature of the forward envelope of the gable wall from slag pumice concrete, thickness of 300 mm (Sp3), gas silicate spandrel stripe, thickness of 250 mm (Sp2) and window insets from YTONG, thickness of 250 mm (Sp1). The second object is jointly insulated. Picture 5 demonstrates higher surface temperatures and thus higher heating discharge.



Object Parameter	**Value**
Atmospheric Temperature	-2.0 °C
Label	**Value**
Sp1	0.1 °C
Sp2	0.2 °C
Sp3	-0.9 °C
Sp4	0.5 °C

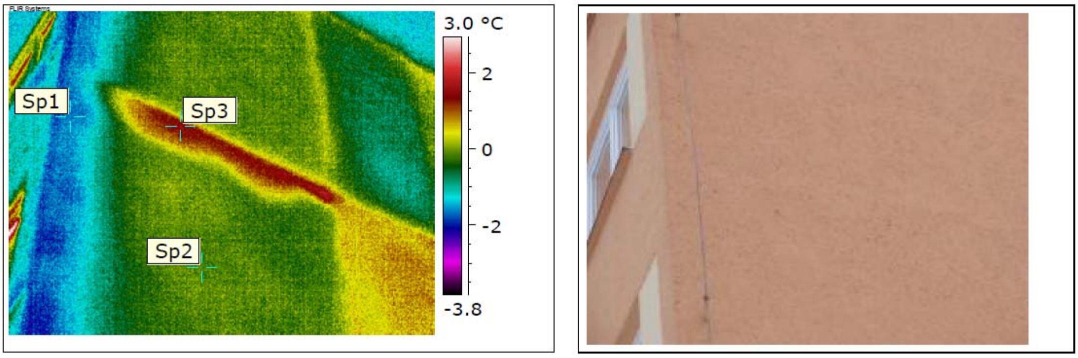
Fig. 5 Picture by thermocamera – west view (uninsulated object GOS)



Object Parameter	**Value**
Atmospheric Temperature	-2.0 °C
Label	**Value**
Sp1	-1.5 °C
Sp2	-1.6 °C
Sp3	-1.9 °C
Sp4	0.6 °C

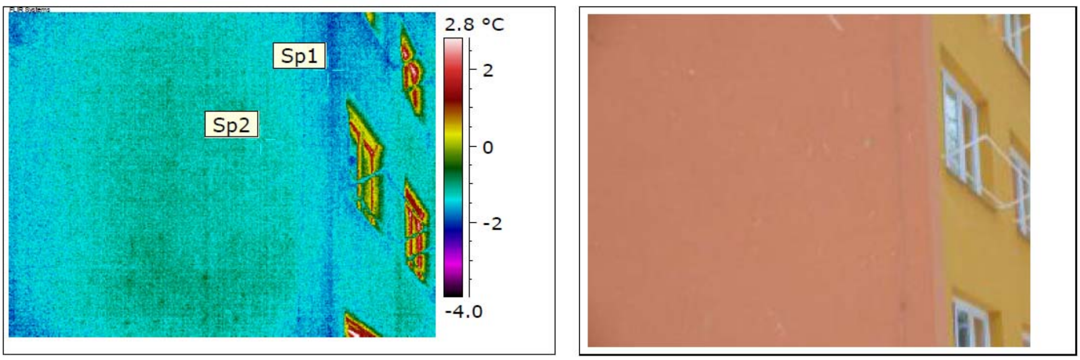
Fig. 6: Picture by thermocamera - west view (insulated object GOS)

The building envelope of the block of flats (Fig. 7 and 8) forms in gables panels from slag pumice concrete (thickness of 300 mm). In an uninsulated object, there are not only higher surface temperatures, but also a thermal bridge at the joint of the panels in the gable (Sp3).



Object Parameter	Value
Atmospheric Temperature	-2.0 °C
Label	**Value**
Sp1	-1.6 °C
Sp2	-0.1 °C
Sp3	1.6 °C

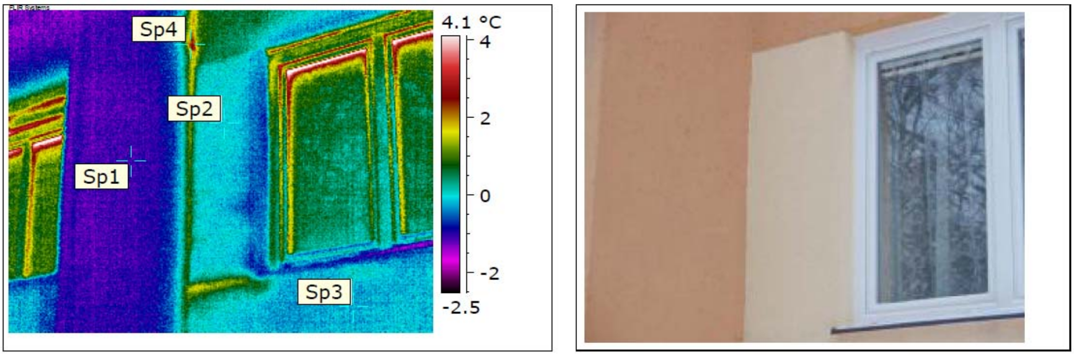
Fig. 7: Picture by thermocamera – north view (uninsulated object GOS)



Object Parameter	Value
Atmospheric Temperature	-2.0 °C
Label	**Value**
Sp1	-1.9 °C
Sp2	-1.4 °C

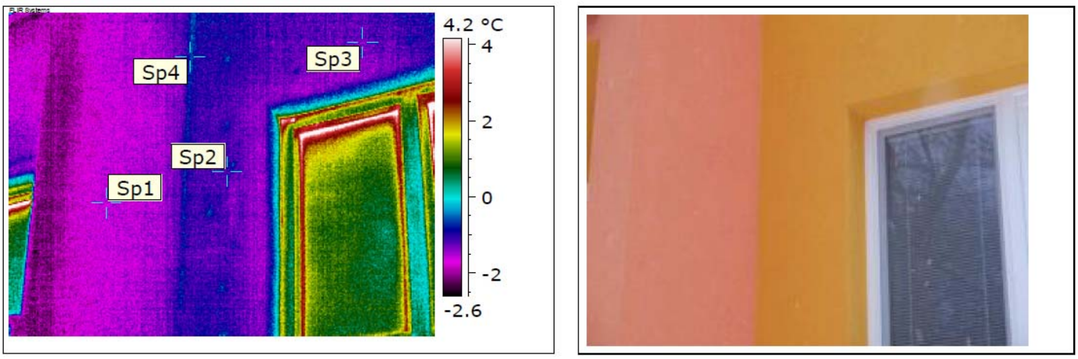
Fig. 8: Picture by thermocamera – north view (insulated object GOS)

East face of building (Fig. 9 and 10) is divided by a vertical stripe of forward loggias. It is again possible to observe a thermal bridge in the corner of the loggia where the temperature of +2.5°C was measured (Sp4).



Object Parameter	Value
Atmospheric Temperature	-2.0 °C
Label	**Value**
Sp1	-1.2 °C
Sp2	0.0 °C
Sp3	-0.1 °C
Sp4	2.5 °C

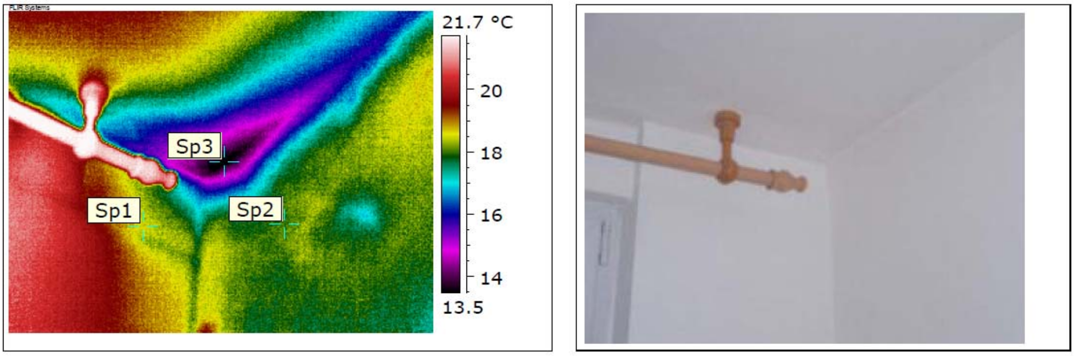
Fig. 9: Picture by thermocamera – east view (uninsulated object GOS)



Object Parameter	Value
Atmospheric Temperature	-2.0 °C
Label	**Value**
Sp1	-1.8 °C
Sp2	-1.3 °C
Sp3	-1.5 °C
Sp4	-0.7 °C

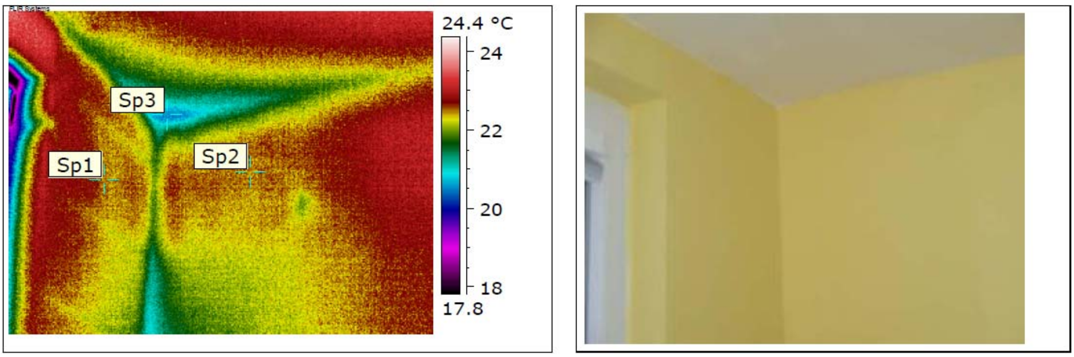
Fig. 10: Picture by thermocamera – east view (insulated object GOS)

The last two thermographs from the interior (Fig. 11 and 12) show the south-east corner (a joint of a ceiling and enclosure walls). It is a joint of a peripheral panel from slag pumice concrete (Sp2) and window insets from YTONG (Sp1). The temperatures in the corner are distinctively lower which can result in the surface condensation of the water vapour in this part and mould occurrence.



Object Parameter	Value
Atmospheric Temperature	22.0 °C
Label	**Value**
Sp1	18.3 °C
Sp2	17.9 °C
Sp3	13.2 °C

Fig. 11: Picture by thermocamera – interior (uninsulated object GOS)



Object Parameter	Value
Atmospheric Temperature	23.0 °C
Label	**Value**
Sp1	22.4 °C
Sp2	22.2 °C
Sp3	20.6 °C

Fig. 12: Picture by thermocamera – interior (insulated object GOS)

5 SUMMARY

The modellings using software AREA 2009 (see Tab. 1) were carried out to enable a better co MParability and and to show an idea of seriousness of the faults of this detail. The modellings proved serious faults of this detail in the original type of construction (Fig. 13 and 14). In the inner corner, there was the lowest surface temperature of only +4.27 °C because of norm environmental conditions. Thus, the dew point temperature was exceeded which is under the given conditions +11.11 °C.

10.2478/v10160-010-0007-2

Tab. 1 Environmental conditions

Design outside temperature θ_{ae} [°C]	-15
Design inside air temperature θ_{ai} [°C]	+21
Design relative outside air humidity φ_e [%]	84
Design relative inside air humidity φ_i [%]	55
Thermal resistance of heat transfer in the interior R_{si} [m^2 K/W]	0,13
Dtto for the calculation of the condensation and surface temperatures R_{si} [m^2 K/W]	0,25
Thermal resistance of heat transfer in the exterior R_{se} [m^2 K/W]	0,04
Dtto for the calculation of the condensation and surface temperatures R_{se} [m^2 K/W]	0,04

In pictures 13 and 15 (in the left part), the blue isotherm represents a critical inside surface temperature. In the immediate surroundings of the inside construction surface, the critical relative air humidity of 80 per cent is achieved. This value represents a criterion when the risk of mould occurrence appears. The red isotherm demonstrates the dew point temperature achieved in the construction where the relative humidity near the surface is 100 per cent. If it drops below this value, condensation occurs.

Pictures 13 and 15 show that the slag pumice concrete panel doesn‘t conform to the parameters required by heat engineering which results in lower temperatures near the inside surface of the panel.

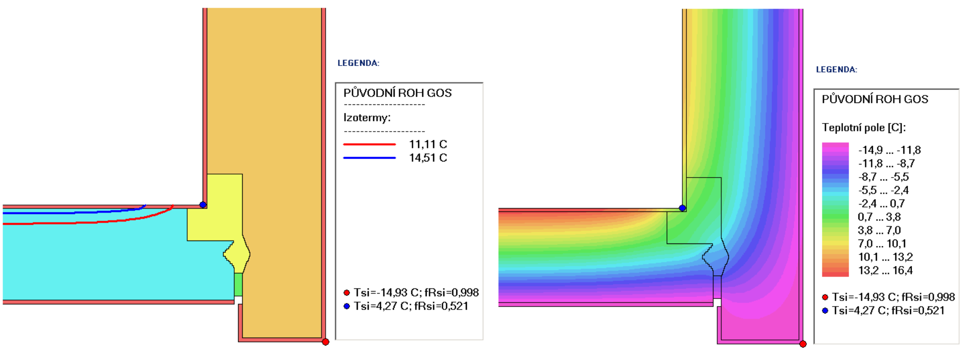


Fig. 13: Isotherms and fields of temperature (uninsulated object GOS)

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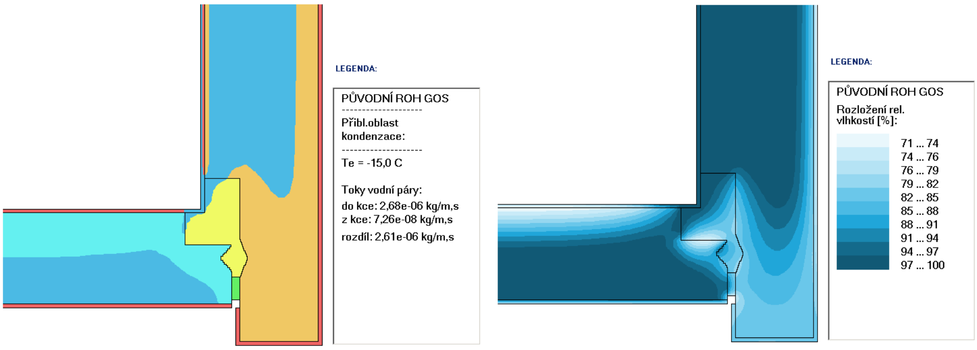

Fig. 14: The area of humidity condensation and distribution of relative humidity in the construction (uninsulated object GOS)

The last picture which refers to the original structural design (Fig. 14 – left part) shows a large condensation area in both constructions. Concerning the humidity balance in the construction, only the faced panel from gas silicate (see Tab.2) matches the requirements. On the other hand, the slag pumice concrete gable panel reaches a serious negative balance of the condensed and evaporated water vapour from the construction.

Modellings for the modified condition have been carried out in the computer program AREA 2009 to verify if the suggested solutions will be efficient. Follow-up measurements by thermocamera confirmed the result from the modelling.

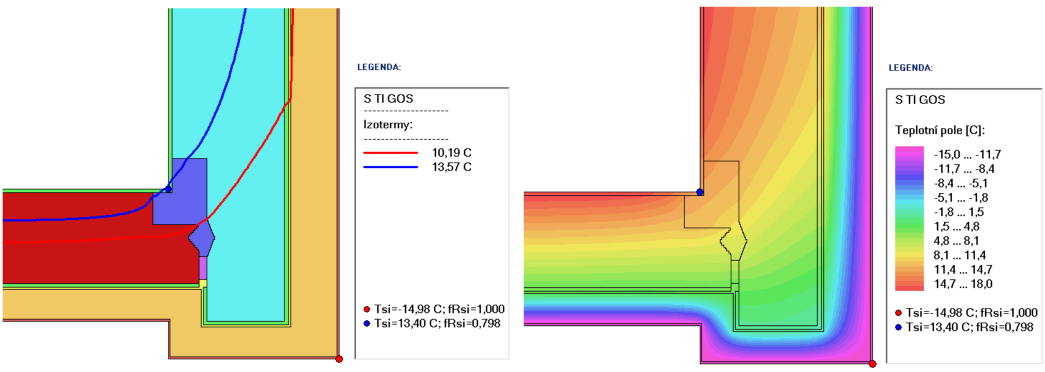

Fig. 15: Isotherms and fields of temperature (insulated object GOS)

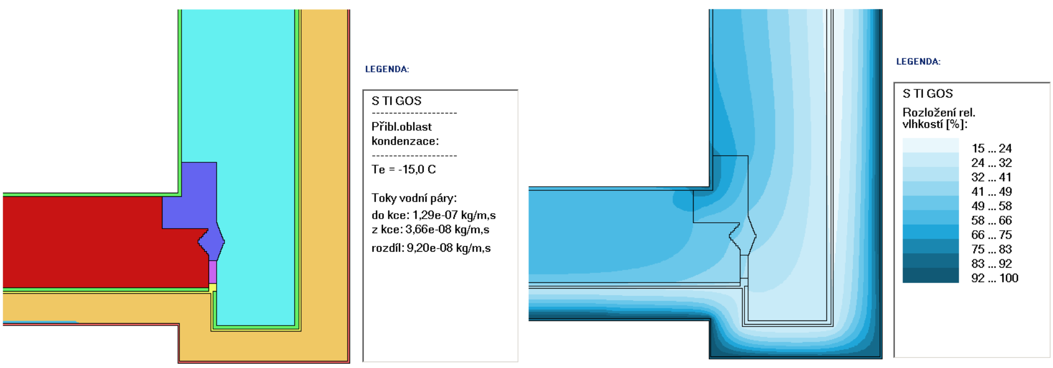

Fig. 16: The area of humidity condensation and distribution of relative humidity in the construction (insulated object GOS)

It is obvious from picture 15 that there is no inside surface condensation. The risk of the mould occurence on the surface is present only in a small area in the inner corner.

The lowest calculated surface temperature is 13.40 °C which represnts the exceeding of the limit value by 0.17 °C. Picture 15 shows that the distribution of temperatures in both peripheral walling panels is approximately the same. Only with the face of building the field of temeperatures is thicker, which is caused by a generally smaller thickness of the construction as co MPared to the gable of the object.

Tab. 2 Heat engineering assessment of the structural [Teplo 2009, Svoboda]

construction	$f_{Rsi} \geq f_{Rsi,N}$ [-]	$U \leq U_N$ [W/(m^2.K)]	$M_c \leq M_{c,N}$ [kg/(m^2.a)]	$M_c < M_{ev}$ [kg/(m^2.a)]
ORIGINAL CONDITION GOS–66				
PSK panels	0,821 > 0,789	0,79 > 0,38	0,074 < 0,5	0,074 < 3,8253
Result	**Fulfilled**	**unfulfilled**	**Fulfilled**	**Fulfilled**
SPB panels	0,649 < 0,789	1,71 > 0,38	7,0762 > 0,5	7,0762 > 2,1082
Result	**unfulfilled**	**unfulfilled**	**unfulfilled**	**unfulfilled**
INSULATED CONDITION GOS–66				
PSK panels	0,922 > 0,789	0,31 < 0,38	0,1268 > 0,1	0,1268 < 4,1635
Result	**Fulfilled**	**Fulfilled**	**unfulfilled**	**Fulfilled**
SPB panels	0,926 > 0,789	0,29 < 0,38	0,0269 < 0,1	0,0269 < 4,1911
Result	**Fulfilled**	**Fulfilled**	**Fulfilled**	**Fulfilled**
f_{Rsi}	Temperature factor of the inside surface			
$f_{Rsi,N}$	Required value of the lowest temperature factor of the inside surface			
U	Heat passage coefficient			
U_N	Required value of heat passage coefficient			
M_c	Annual amount of the condensed water vapour inside the construction			
$M_{c,N}$	Required annual amount of the condensed water vapour inside the construction			
M_{ev}	Annual amount of evaporable water vapour inside the construction			

It is possible to see a striking improvement of the suggested and performed adjustements when co MParing the size and locations of the condensation in the construction as shown in pictures 14 and 16. In the original design, surface condensation on the inside surface of the cladding occurred, while in the modified condition condensation occurs only near the outside surface of the contact insulation system.

By means of the summary of thermocamera measuring and modelling in software AREA 2009, it has been proved that the insulation of the existing envelope of the object GOS-66 Svornosti Street 57 in Ostrava – Zábřeh is a better solution when considering thermal comfort and humidity. In In both designs, natural air infiltration was prevented by replacing of the original loose wooden double windows with new plastic windows. As a result, in winter months a risk of increase of relative humidity in rooms with irregular ventilation appears. At strikingly lower surface temperatures in the interior of an uninsulated object, surface condensation of the water vapour and thus moulds might occur.

10.2478/v10160-010-0007-2

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