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THE IMPROVEMENT OF THERMAL PROPERTIES OF CLADDING OF THE EDUCATIONAL INSTITUTION IN FRYDEK MISTEK

VYLEPŠENÍ TEPELNĚ TECHNICKÝCH VLASTNOSTÍ OBVODOVÝCH KONSTRUKCÍ VÝCHOVNÉHO ÚSTAVU VE FRÝDKU - MÍSTKU

Abstract

Thermocamera can be used for the assessment of building envelope. Thermal bridges and their seriousness can be detected by thermocamera. We used these measurements to compare the detail of contact building envelope with the column, which is made slag-pumice concrete in the original building and the same detail in the same building after thermal insulation.

Keywords

Thermocamera, assessment of building envelope, thermal bridges, thermal insulation, educational institution.

Abstrakt

Termovizní kameru lze využít k posuzování obvodových plášťů budov. Tepelné mosty a jejich závažnost mohou být odhaleny právě termokamerou. Využili jsme tato měření pro porovnání detailu styku obvodového pláště a sloupu ze struskopemzobetonu původního objektu a po jeho zateplení.

Klíčová slova

Termovizní kamera, posuzování obvodových plášťů, tepelné mosty, tepelná izolace, obvodová konstrukce, výchovný ústav.

1 INTRODUCTION

Importance of design measures for a decreasing of heating costs is growing together with the increasing energy prices. Demands of users on housing are higher and it is reflected in standards that increase requirements on a thermal protection of building structures.

Thermo-visual measurement is an up-to-date non-destructive way of external cladding inspection and detection of possible weak points – thermal bridges. Nowadays the thermo-visual measurement is becoming a standard. In our case it was used for the assessment and comparison of effectiveness of implemented design measures in educational institution in Frydek – Mistek.

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Figure No.1: Building under consideration before and after implementation

2 BUILDING DESCRIPTION

The evaluated building of the educational institute is placed in Frydek Mistek. It is a mounted frame created by ZDS+MS standardization. This design system from the year 1964 was named as 3.5^{o} technology.

Figure No. 2: Detail of building under consideration from side of interior and exterior before thermal insulation

We focused on a detail of contact between the cladding and column during modelling and measurement. Vertical peripheral columns with dimensions 300 x 600 mm are made from slug-pumice concrete SPB135 and window sill ledgements with thickness of 300 mm are made from slug-pumice concrete SPB60. Because of the purpose of accommodation the surface of windows in the whole building has been reduced. Filling of the window sills and vertical parts of the cladding were made from building blocks IFT with thickness of 300 mm. The columns are ejected by 100 mm in front of the original window sill ledgements. The fillings are ejected by 100 mm as well, but according to the investor's requirement the cladding after the contact thermal insulation had to be without any protruding structures (Figure 3).

Contact insulation from expanded polystyrene with the thickness of 200 mm was used for the existing window sills and the new filling from the level of rough floor on the first floor. Polystyrene with the thickness of 100 mm was used on the columns and peripheral structures for alignment of the whole facade to one plane.

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3 THERMAL-TECHNICAL COMPARISON OF MODELS

Modelling in software AREA 2009 (see Table No. 1) was carried out for a better comparability and for conception of thermal and technical parameters of this detail. The modelling showed serious drawbacks of this detail in the original version.

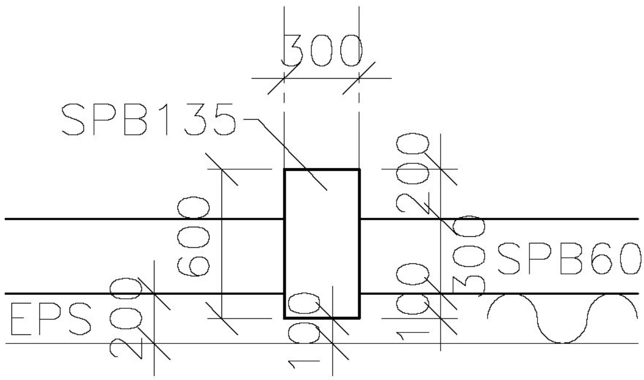

Figure No. 3: Solved detail of horizontal cross section of column with thermal insulation and window sill made from slag-pumice concrete

Table No. 1: Limit conditions

Design external temperature θ_{ae} [°C]	- 15
Design temperature of interior air θ_{ai} [°C]	+ 21
Design relative humidity of external air φ_e [%]	84
Design relative humidity of interior air φ_i [%]	55
Thermal resistance of heat transfer in interior R_{si} [m^2 K/W]	0.13
Thermal resistance of heat transfer in interior for calculation of condensation and surface temperatures R_{si} [m^2 K/W]	0.25
Thermal resistance during heat transfer in exterior R_{se} [m^2 K/W]	0.04
Thermal resistance during heat transfer in exterior for calculation of condensation and surface temperatures R_{se} [m^2 K/W]	0.04

Blue isotherm in the Figures No. 4 and 6 (left part) represents critical interior surface temperature, when critical 80% relative air humidity is achieved at the vicinity of the structure inner surface. This is a criterion that signals a danger of mould growth. Red isotherm shows and achievement of dew point in the structure, when the relative humidity close to the surface is 100%. Condensation takes place in case of a drop below this value.

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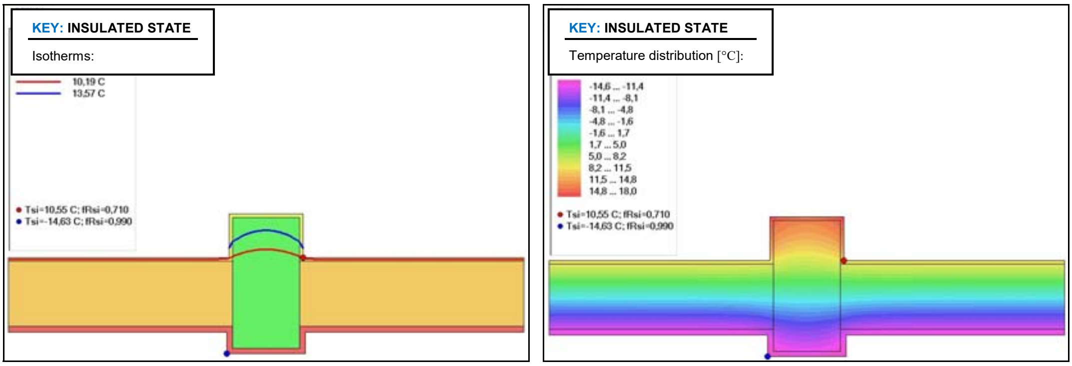


Figure No. 4: Isotherms and temperature fields (detail without thermal insulation)

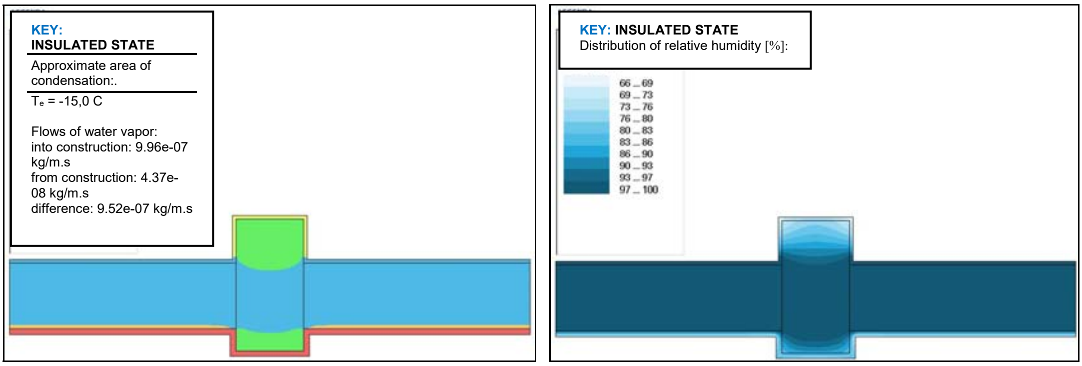


Figure No. 5: Area of humidity condensation and distribution of relative humidity in structure (detail without thermal insulation)

It is evident from the previous figure (Figure No. 4) the slag-pumice concrete panel does not fulfil the required parameters from the standpoint of thermal technique. It takes effect by lower temperatures on the panel inner surface. Temperature field modelling in the Figures No. 4 and 6 (right part) shows marked differences.

Big condensation area in both structures is visible on the next figure that is related to the original structure design (Figure No. 4 – left part). The slag-pumice concrete window sill panel and column reach a serious negative balance of condensed and evaporated water vapour from the structure according to the humidity balance.

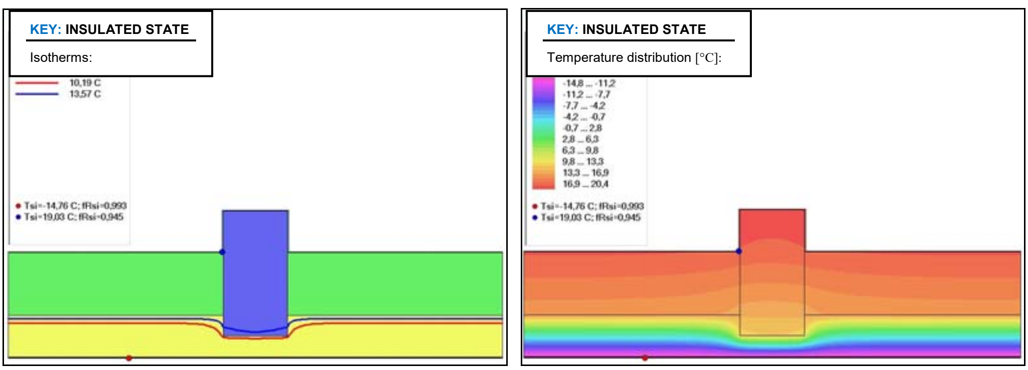


Figure No. 6: Isotherms and temperature fields (detail with thermal insulation)

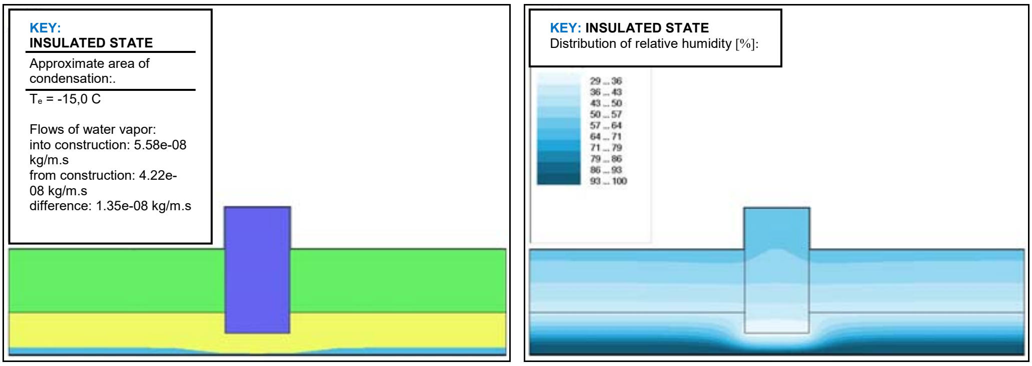


Figure No. 7: Area of humidity condensation and distribution of relative humidity in structure (detail with thermal insulation)

Improvement of proposed and implemented changes is visible from a comparison of size and place of condensation in the structure according to the Figures No. 5 and 7. Even surface condensation tooks place on the inner surface of the cladding in the original version, while in case of the modified state the condensation takes place only close to the external surface of the contact thermal insulation system. Increasing of lifespan of the load-bearing structure as well as the whole building has been achieved owing to the shift of condensation area to the thermal insulating material of the façade.

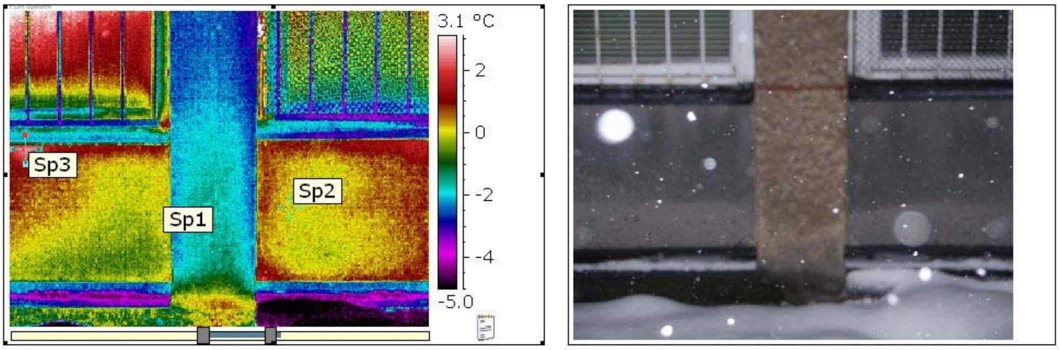
4 EVALUATION OF THERMOGRAPHIC MEASUREMENT

Thermography is a measuring method that displays incident or radiated infra-red radiation of a surface in a pallet of colour shade. Each shade represents certain temperature range. Fact that the radiation depends directly on the building surface temperature enables the thermocamera to calculate and display the temperature. The thermographic measurement does not measure the building surface temperature directly, but it measures only radiation from the surfaces. An incorrectly adjusted emissivity of structure surfaces can influence substantially an appearance of the thermogram and it can cause a wrong interpretation of measured values. Also strong and irregular wind can influence the results, because it can cause a hardly definable cooling of individual surfaces of the structures.

Measurement before total reconstruction was carried out by thermographic system ThermaCAM-B4 on 18th February 2009 at 5 p.m. There was overcast sky, external temperature was –3 °C and relative humidity of external air was 80 %. Interior air temperature in the measured room was +23 °C with relative humidity 35 %.

The second thermographic measurement was carried out after the finishing of construction works on 10th January 2011 at 10 a.m. There was overcast sky, external temperature was –1 °C and relative humidity of external air was 85 %. Interior air temperature in the measured room was +23 °C with relative humidity 45%.

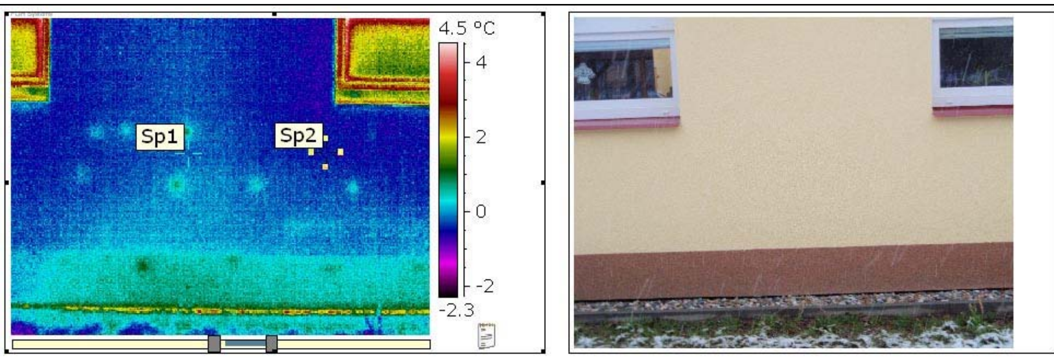
You can see surface temperatures of cladding made from slag-pumice concrete without thermal insulation from the exterior side in the Figure No. 8. Higher temperature was measured on the window sill panel made from SPB60 in comparison with column made from SPB135 (point Sp1) at the points Sp2 and Sp3 This is caused by a higher thickness of the column and its higher thermal resistance, but also by central heating behind the window sill panel. There is a substantially increased thermal flow under external flashing of the window sill that causes a higher heating discharge at the point Sp3.



Parameters of building	*Value*
Atmosphere temperature	*-3.0 °C*
Relative humidity	*80.0%*
Details	***Value***
Sp1	*-1.5 °C*
Sp2	*0.2 °C*
Sp3	*2.6 °C*

Figure No. 8: Thermo-visual image of building without thermal insulation (exterior)

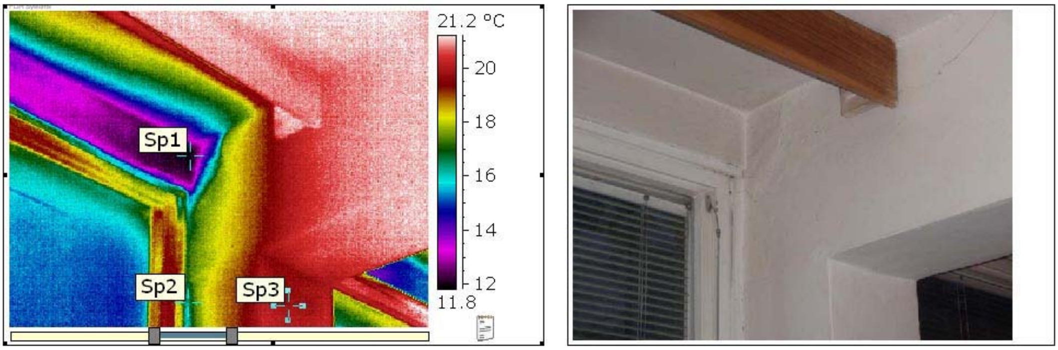
Identical measured detail after the contact thermal insulation installation is in the Figure No. 9. The surface temperature of the cladding insulated by means of expanded polystyrene is nearly the same both at the place of column (Sp1) and at the place of the window sill (Sp2).



Parameters of building	*Value*
Atmosphere temperature	*-1.0 °C*
Relative humidity	*85.0%*
Details	***Value***
Sp1	*0,3 °C*
Sp2	*0.5 °C*

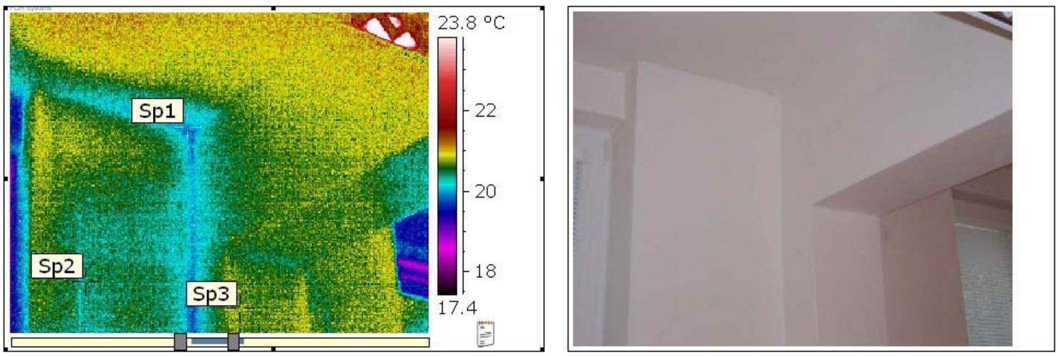
Figure No. 9: Thermo-visual image of building with thermal insulation (exterior)

You can see a difference of surface temperatures from the side of interior in the corner next to the ceiling structure before thermal insulation installation on the following figures (Figure No. 10) and after the installation (Figure No. 11). Noticeably higher temperatures are visible above the window at the point Sp1 in the Figure No. 10. This could cause a surface condensation of water vapour at given place and attack of the inner surface of the structure by mould. The problem did not arise because of a natural infiltration of air through original wooden double windows. A noticeable improvement of the studied detail is evident after the lining construction and after the finishing of other construction works (Figure No. 11).



Parameters of building	*Value*
Atmosphere temperature	*23.0 °C*
Relative humidity	*35.0%*
Details	***Value***
Sp1	*11.9 °C*
Sp2	*16.3 °C*
Sp3	*19.9 °C*

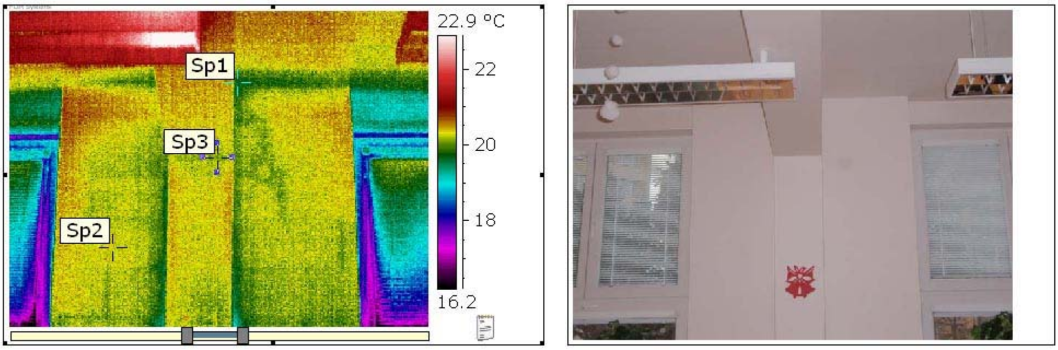
Figure No. 10: Thermo-visual image of building without thermal insulation (interior)



Parameters of building	*Value*
Atmosphere temperature	*23.0 °C*
Relative humidity	*45.0%*
Details	***Value***
Sp1	*19.9 °C*
Sp2	*20.3 °C*
Sp3	*20.9 °C*

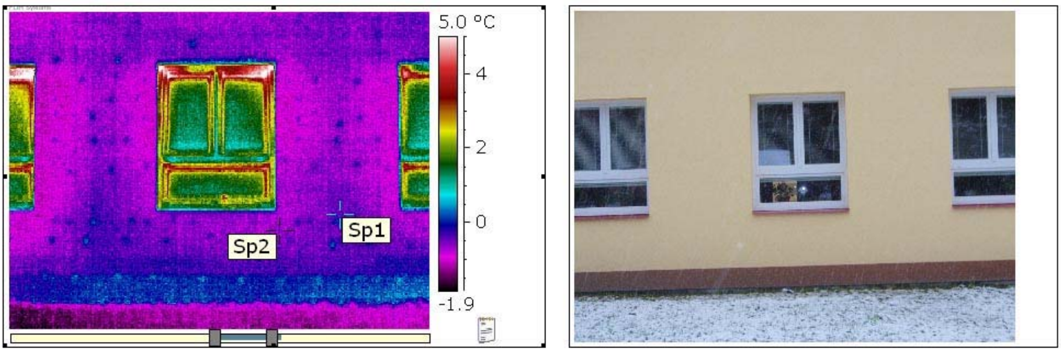
Figure No. 11: Thermo-visual image of building with thermal insulation (interior)

Influence of construction changes of the cladding structure from the interior side (Figure No 12 and from the exterior side (Figure No. 13) is visible in the Figures No. 12 and 13). The measured surface temperatures are nearly homogeneous in both following thermograms.



Parameters of building	*Value*
Atmosphere temperature	*23.0°C*
Relative humidity	*45.0%*
Details	***Value***
Sp1	*19.6 °C*
Sp2	*20.2 °C*
Sp3	*20.0 °C*

Figure No. 12: Thermo-visual image of facade with thermal insulation from side of interior



Parameters of building	*Value*
Atmosphere temperature	*-1.0°C*
Relative humidity	*85.0%*
Details	***Value***
Sp1	*-0.3 °C*
Sp2	*-0.6 °C*

Figure No. 13: Thermo-visual image of facade with thermal insulation from side of exterior

5 CONCLUSION

Modelling of temperature fields in the structures is more accurate and faster in case of application of computer technologies. Nevertheless even in these programs we can only theoretically approach near to the real structure. It is determined by geometry of the structure, which never correspond fully to the reality, and also by physical properties of the structure that change during time. Therefore the results of some idealized model that resemble the evaluated structure are the outputs of the test. It is better to complete the results by non-destructive measurement by thermocamera after the reality investigation that can help us to see the structure from thermal and technical point of view and to detect some weak places.

Modelling in Area 2009 program as well as measurement by thermocamera proved a significant improvement of thermal and technical properties of cladding with the column. An improvement is evident inside the interior according to the modelling. The above-described thermal insulation has improved moisture conditions inside the structure as well as on its inner surface.

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