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In situ monitoring of internal surface temperature of the historic building envelope

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Abstract

Historical building envelope is characterized by a large accumulation that impact is mainly by changing the inner surface temperature over time. The minimum value of the inner surface temperature is set Code requirements. In the case of thermal technology assessment of building envelope contemplates a steady state external temperature and internal environment, thereby neglecting the heat accumulation capacity of building envelopes. Monitoring surface temperature in real terms in situ shows the real behavior of the building envelope close to reality. The recorded data can be used to create a numerical model for the simulation.

Key words: inner surface temperature, simulation, historical building envelope

1 Introduction

One of the basic criteria for the evaluation of building envelope from thermal technology is the internal surface temperature - hygienic criteria. Decreasing the inner surface temperature of building envelope is characteristic of thermal bridges. As a result of decrease of the surface temperature of building envelope are the condensation of vapor and the formation of mold. Renovation of a historic building envelope is a difficult process; the task is at a minimum interference to the envelope to maximize the impact of renovation. In many cases, it is accompanied by a lack of knowledge of the building envelope. Especially lack the knowledge that has to be examined fast and by nondestructive method in the building envelope (geometry, building envelope, thermo-physical properties of construction materials) [1].

Measurement in real terms in situ allows us to record the effects of changes in external and internal environment on the building envelope. The acquired measured data can be used to create a numerical model for the simulation. Simulation as a research tool allows us to understand the behavior of the building envelope. It enables more accurate and higher quality proposal of the measures to improve the hygrothermal behavior. Mainly it allows the preservation of historical value of centuries old building envelope [2], [3].

2 Methodology

The aim of experimental measurement was recording surface temperature changes due to the dynamic boundary conditions. Measurement is influenced by the constantly changing conditions of the internal and external environment. According to STN 730540 is valid that ceilings and floors in spaces with a relative humidity of air φi ≤ 80% must be in every place of the inner surface temperature θsi expressed in ° C, which is safely above the dew point temperature and eliminates the risk of mold creation. For standardized terms of indoor air is θsi value $\theta_{si,80}$ = 12,6°C [4]. In evaluating the hygienic criteria for the building envelope are used simplified stationary conditions of external and internal environment [5]. Such evaluation shall not take into account effect of material parameters such as density and specific heat capacity. These parameters indicate the thermal storage capability of building envelopes [6], [7], [8], [9], [10].

For measuring the temperature there are used the sensors based on the type of tip resistance without PT, Ntc and NiCr with a measuring range of -50 to +125 ° C and hundredth resolution on linear accuracy ± 0,05 K. The heat flow density is measured in the range -260 to +260 W/m^2 with a resolution hundredth W/m^2.

2.1 Monitoring of the historic building envelope

The surface temperature was monitored on the building envelope, where significant architectural features and the variety of building materials can give rise to thermal bridges. From an architectural point of view are important elements and in terms of building physics are the same elements - critical thermal bridges. The measurements were carried out on the building envelopes at the premises of the bank (Figure 1) and at the premises of Burghers house (Figure 7). The monitored points were placed to measuring critical segments of building envelope. The aim was to capture the anticipated deformation temperature field in building envelope. Measurements were short-term (7 days), carried out in January and February.

Measurement consisted of recording the inner surface temperature using temperature sensors and the density of heat flow. Measurement data of interior surface temperature may in turn serve for the numerical model. This is way how analyze all types of building envelopes in terms of material solutions and the specific geometry.

2.1.1 Monitoring of the bank building envelope



Figure 1: Bank and marking the room in which was made the measurement, stone window ledge with the initial profiling, Source: (KPÚ, Košice)

In the building envelope has been identified stone ledge (tuff). Ledge width was of approx. 250 mm and height of approximately 150-200 mm. From the exterior is stone cornice covered with stucco. The sensors were placed with the north and east of the building envelope in the same places.

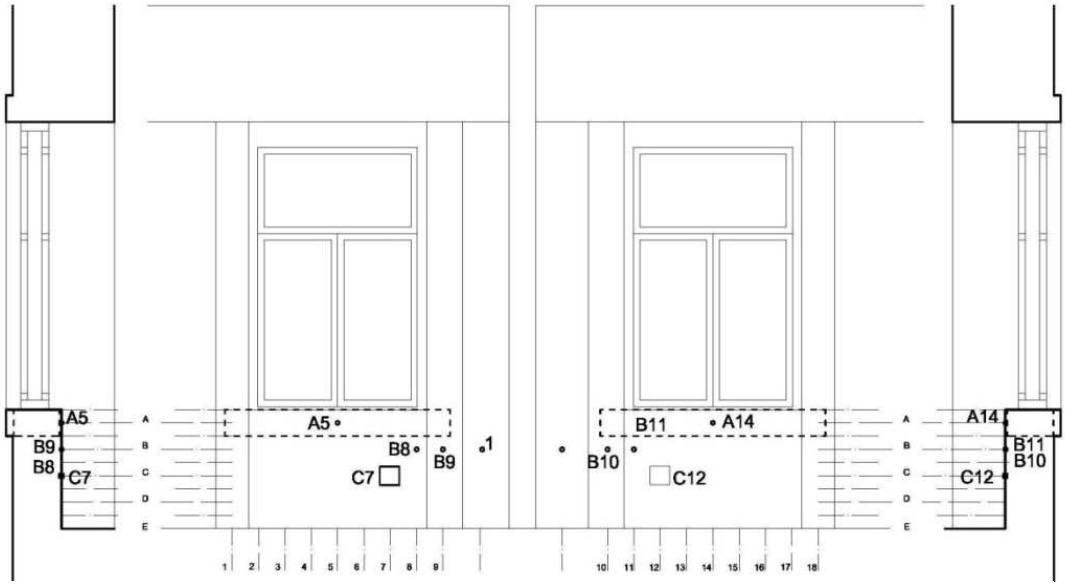


Figure 2: Scheme of the location of the surface temperature and the heat flow density sensors

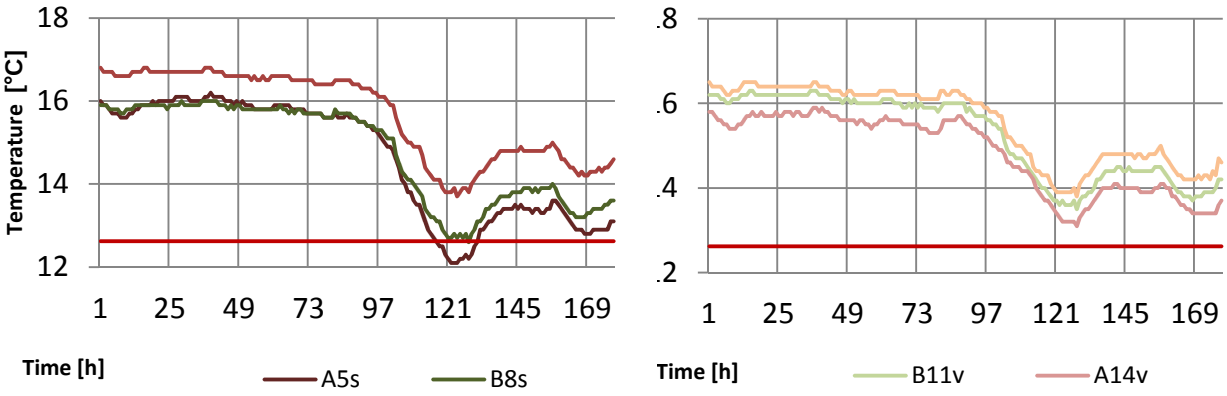


Figure 3: Surface temperature: left on the north building envelope, right on the east building envelope

From a comparison of sensor surface temperature with a different orientation to the cardinal points showed that place of the stone parapet ledge is within 4 days A5s surface temperature (north facing) higher than A14v (east facing). The temperature difference between the northern and eastern orientation is 0.20K (Figure 4 - left).
From a comparing of the surface temperatures measured at the point of the retreating parapet masonry B8S and B11v is the value of the measured surface temperatures on the north wall below the eastern wall by about 0.5K (Figure 4 - right).

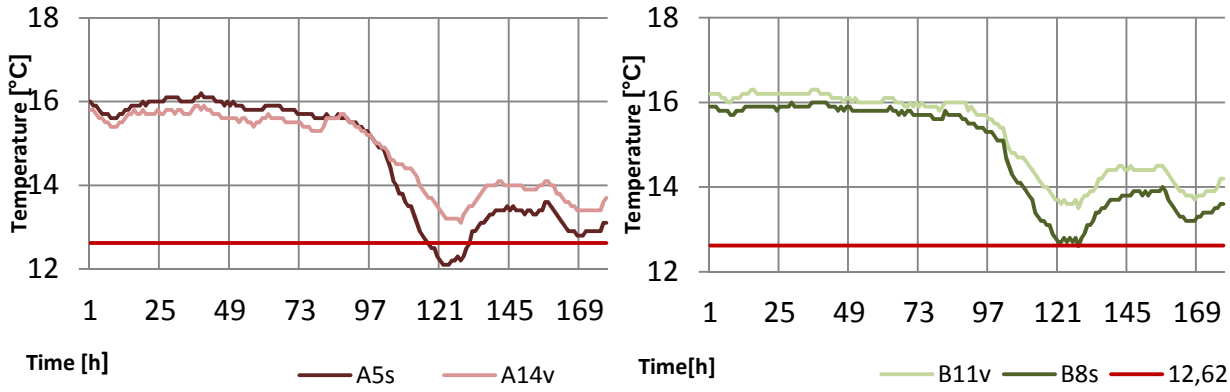


Figure 4: Comparison of surface temperatures measured in the same areas of the building envelope with a different orientation to cardinal

The highest temperature of the inner surface is recorded on the B9s, B10v sensors - higher thickness of the building envelope and enlarges the surface in favorable boundary conditions (higher indoor heated area).
In view of the requirements of hygiene criteria are the average values of temperature on the inner surface above the standard required by the lowest surface temperature (Figure 4). Below the hygienic criteria decreased A5s value.

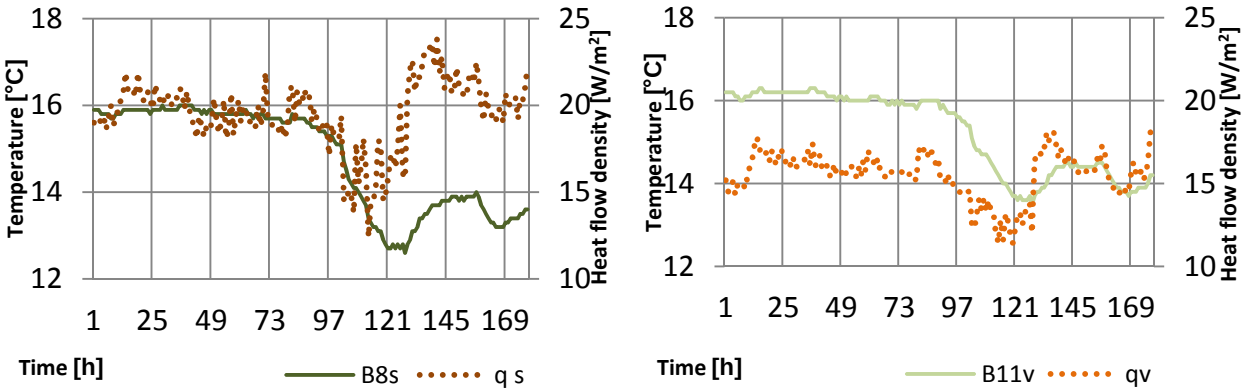


Figure 5: Heat flow density and surface temperature: left on the north building envelope, right on the east building envelope

Heat flow density on the building envelope with the northern orientation is affected by reducing the thermal resistance of the building envelope, possibly due to the stone parapet, which was defined by the higher value of the coefficient of thermal conductivity.
On the east side is observed a reduction in the density of the heat flow, which may by result from the effect of solar radiation for reducing temperature gradient.
The value of the internal surface resistance of the building envelope (R_{si}) expressed as median values calculated from the heat transfer coefficient h_i and for the monitored period is 0.15 m^2K /W (sensor B8, C7 (q) located on the building envelope with a north oriented facade) and

0.16 m^2K/W (sensors B11v, C12 (Q) located on the building envelope with an east oriented facade).

2.1.2 Monitoring of the burgher's house envelope



Figure 6: Burghers house and mark the room in which the measurement was performed, terracotta console (Source: KPÚ, Košice)

Sensors were placed at the site above the window ledge and at the point of the retreating parapet masonry. Monitored street facade is oriented to the east side. The results of the measurements in the field of the retreating parapet masonry can be affected in addition to secondary interventions in masonry - ventilation grille of the original gas heating and hot water heating installations tempering adjacent room.

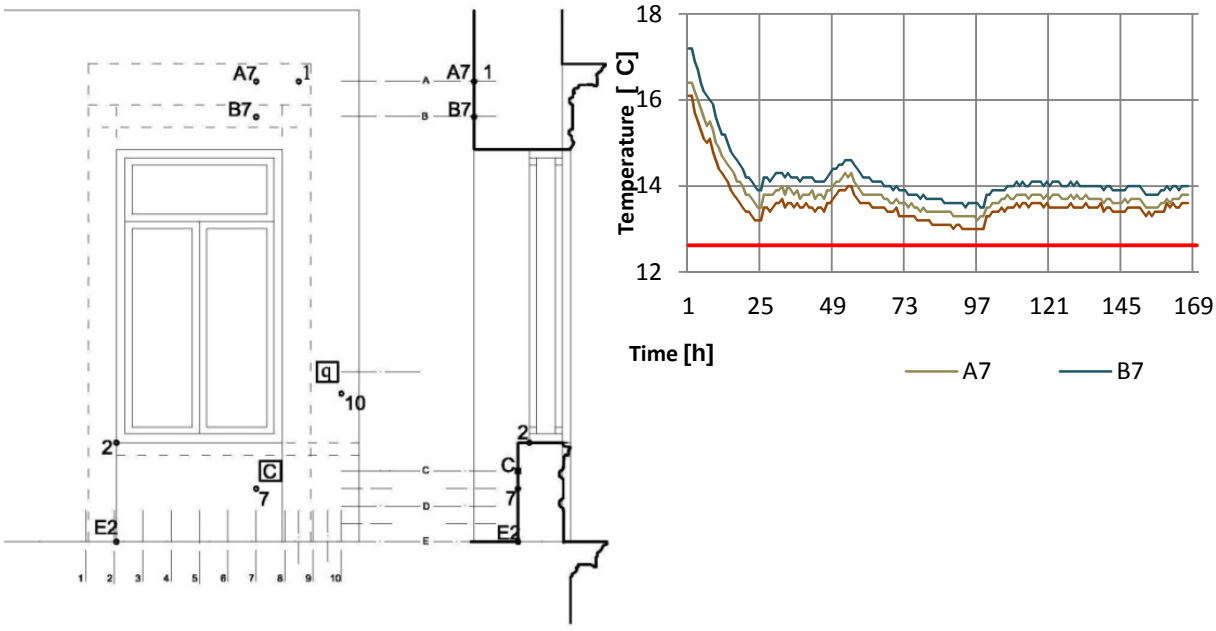


Figure 7: On the left: Scheme of the location of the surface temperature and the heat flow density sensors, on the right: surface temperature at the window lintel

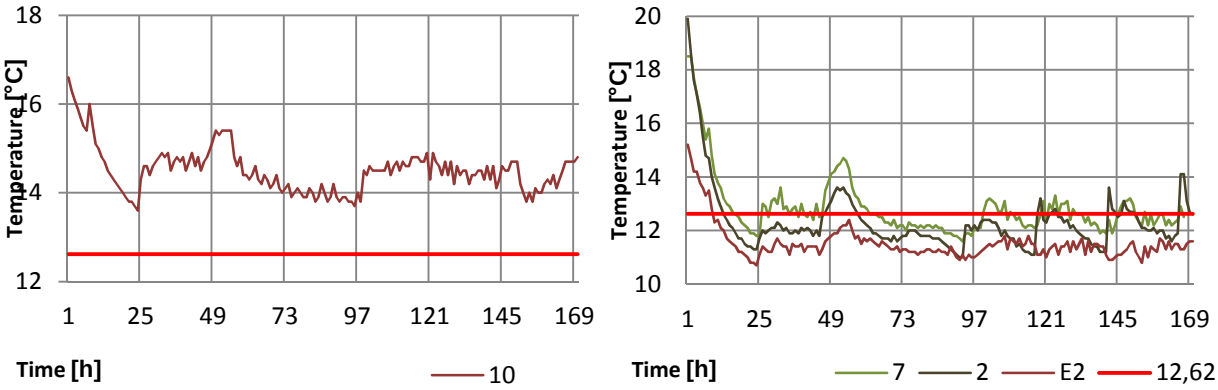


Figure 8: On the left: surface temperature on the building envelope, on the right: surface temperature at the parapet masonry

Interior surface temperatures measured in points 7 and 1 - in place above the window ledge showed lower values compared to the B7 surface temperature measured at the point under the window ledge. The difference of the measured surface temperatures is 0.6 K.
Sensors placed at critical points on window sills 2 and in contact floors and parapet masonry recorded lower values than the surface temperature sensor 7 located at the surface of the masonry parapet.
Surface temperatures in the parapet masonry fall to the border of the hygiene criteria during the whole measurement (Figure 8).

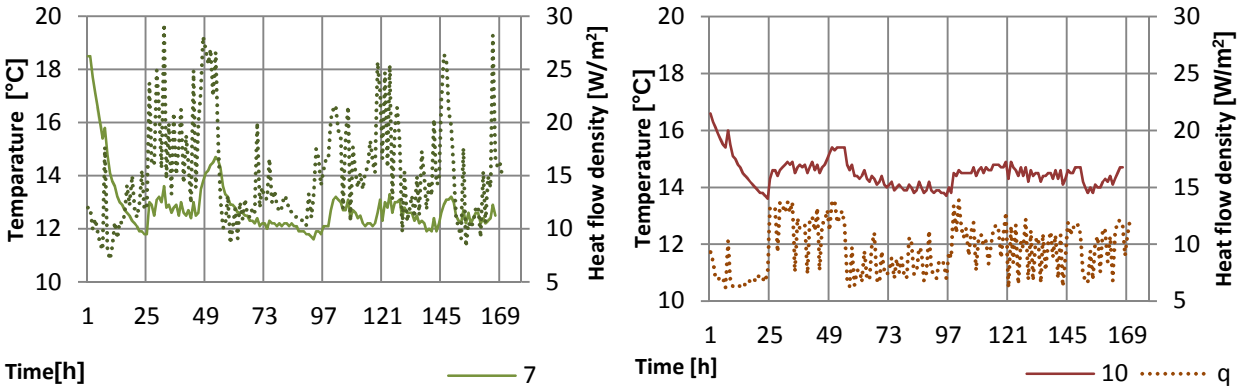


Figure 9: Heat flow density and surface temperature (east building envelope): left at the parapet masonry, right on the building envelope

Heat flow density of the building envelope and parapet masonry is affected by the difference in temperature gradients in addition to the thermal resistance.
The value of the internal surface resistance (R_{si}) expressed as median values calculated from the heat transfer coefficient hi for the monitored period is 0.16 m^2K /W (sensors 7, C (q) located on the parapet masonry) and 0.25 m^2K/W (sensors 10, Q placed on building envelope).

3 Results and conclusion

The purpose was to record the experimental measurements of the surface temperatures of selected buildings in situ, and record the impact of geometric and material thermal bridges in the distribution of temperatures in structures of historical buildings. By measuring changes were noted inside surface temperature of building envelope in non-stationary conditions. Resulted from measurements need to expand knowledge about the material composition of historic buildings and material parameters for defining more accurately describe the changes in surface temperature.

On the bank building were sensors of surface temperature placed on the north and east facade. The measured temperature of the inner surface has fallen below the hygienic criteria only at the place of the ledge stone slabs on the northern building envelope.

Decrease the surface temperature at the point above the window ledge (burgher's house) is not very significant in compared to the surface temperature measured at the point under the window ledge. It can be justified by profiling of the window ledge - cooled by enlarge of the facade area. Not well-known composition of masonry above the window opening can be assume the existence of window lintel with different thermo-physical parameters such as material forming the building envelope.

The low surface temperature at the parapet masonry can be caused by air vents gas heating, which was created during one of the phases of construction development of the building and by other construction impacts associated with the construction adaptation.
The overall impact of facade profiling on building envelope can be described as minimal. Higher effect on surface temperatures has material or significant geometric thermal bridges.

Massive building envelopes show in all cases that the external air temperature drop still conforms to hygienic criteria. Appropriate choice of boundary conditions of the internal environment can keep internal surface temperature above the value of hygienic criteria.

Acknowledgment

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