2-D CRITICAL EXPERIMENT FOR THE ASSESSMENT OF THERMAL AND HYGRIC PERFORMANCE OF AN INTERIOR THERMAL INSULATION SYSTEM

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Abstract

In this paper, a 2-D critical experiment for the assessment of hygrothemal function of hydrophilic mineral wool based interior insulation system is presented. The described experiment is carried out utilizing a specially designed simulating and measuring technology for the analysis of hygrothermal performance of multi-layered building structures in the difference climate conditions. In the semi-scale experiment, the dimensions of the tested specimens are the same as in the real structure. For the climatic data on the exterior side the TRY data for Prague are used. Temperature and relative humidity data typical for residential buildings are assumed on the interior side. In the tested structure, relative humidity, moisture and temperature fields are monitored. Measured field variables are discussed and the functionality of the designed thermal insulaiton system is verified.

Key words: 2-D critical experiment, hygric and thermal performance, interior thermal insulation system

1 Introduction

The application of interior thermal insulation systems on building envelopes is not a natural solution but sometimes there is no other option available. A typical example is a historical building, where the facade has to be kept in its original appearance mostly, and the exterior insulation systems are excluded for that reason. In that case the development of such an insulation system would allow to prevent moisture damages and to upgrade the thermal properties of the envelope as the only reasonable option. A common solution to this problem consists in placing a vapor barrier just under the internal plaster on the surface of the insulation layer, so that both the insulation layer and the load bearing structure are protected against water vapor. However, this is a solution, which can perform well on the theoretical level only. In the practice, it is very difficult to avoid mechanical damage of water vapor barrier placed in such an inappropriate way. In addition, even in the case that the barrier would perform without mechanical damage, the absence of water vapor removal from the interior through the envelope in the winter period, when the air ventilation in the interior is usually limited, can lead to an undesirable increase of relative humidity in the interior and to the worsening of the internal microclimate.

In this paper, a newly developed interior thermal insulation system, which should avoid failures of interior insulation systems given above, is investigated. A 2-D critical experiment is presented where the designed insulation system is applied on a brick wall 600 mm thick, with a fixed window with a wooden frame. The composition of the investigated building envelope is formed from the exterior to the interior by load bearing structure, dual density hydrophilic mineral wool based insulation material DU by Rockwool Inc. of 100 mm thickness, water vapor retarder KAM on cement glue principle developed by Sakret Ltd. in the thickness of 10-15 mm and by water vapor permeable plaster FFP manufactured also by Sakret Ltd. with the thickness of 15 mm.

2 The measuring technology and sample arrangement

A semi-scale system for analysis of hygrothermal performance of multi-layered building structures employed in the presented critical experiment consists of the simulation and the measuring part. The simulation part is composed by two climatic chambers for simulation of semi-real climatic conditions and by connecting tunnel for placing the tested sample. The measuring part consists of the device for monitoring moisture content by Time-Domain Reflectometry method (Easy Test, Ltd) and the device for temperature and relative humidity measurement using the combined probes by Ahlborn, Ltd. (for details see [1]).

The sensors by Easy Test measure the properties of particular building materials, and their calibration is necessary for every material. The process of Easy Test sensors calibration is described in [2,3] in more detail. The Ahlborn sensors measure in fact the properties of the humid air in the tested structure or the properties of the air in the climatic chambers. Therefore, they do not need to be calibrated for every investigated material. The accuracy of combined relative humidity and temperature sensors was randomly tested using saturated salt solutions with specified relative humidity.

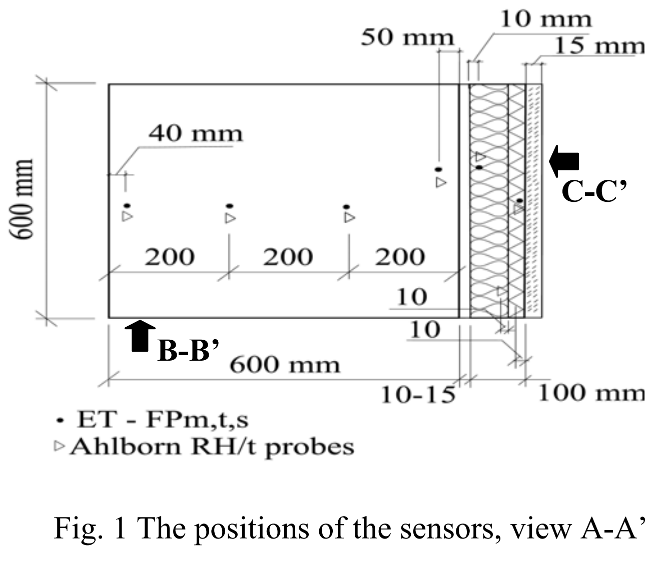

Fig. 1 The positions of the sensors, view A-A’

In the tested structure, the sensors for monitoring moisture content, temperature and relative humidity are placed to the bored holes. The upper part of the bore opening is closed by silicon sealing. The probes for monitoring moisture content measure properties of moist material, therefore it is necessary to fill up back the bored hole by brick powder. The placing of the sensors was chosen regarding to the complex knowledge of fields variables and with respect to the supposed condensation zone. In Figs 1, 2, 3, there is shown placing of the sensors into the tested sample.

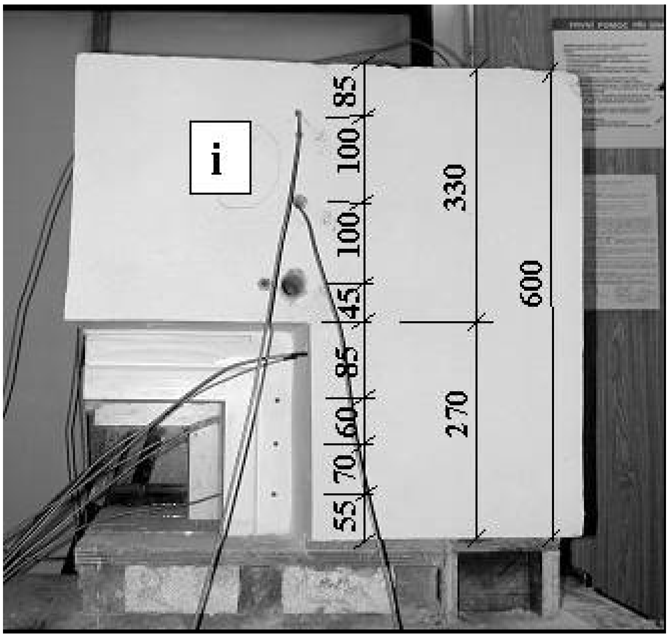

Fig. 2 The positions of the sensors, view B-B’

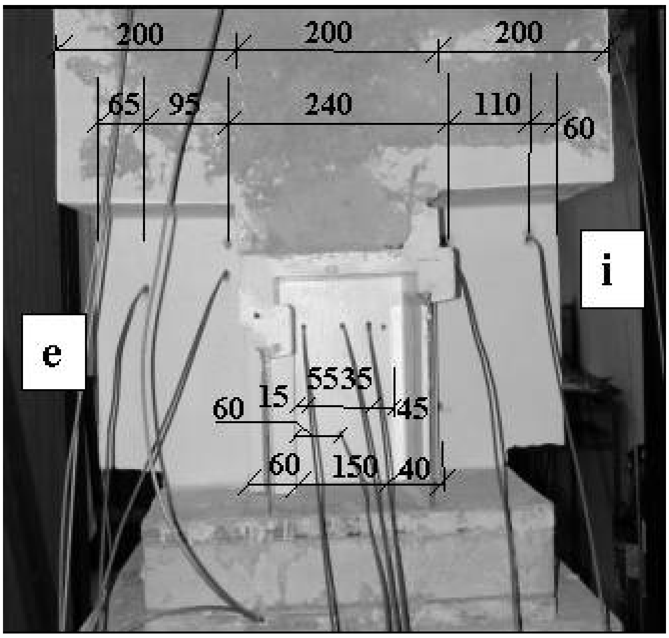

Fig. 3 The positions of the sensors, view C-C’

After the positioning of all sensors, the prepared sample is placed into the connecting tunnel, which is then connected by sleeve connectors with the climatic chambers. The sample, placed into the connecting tunnel, has to be thermally and waterproof insulated from the tunnel wall in order to achieve two-dimensional heat and moisture transport in the tested structure. When the climatic chambers are connected, real climatic conditions chambers are simulated. The measurement was performed for 131 days, hourly climatic data for reference year for Prague starting in October 20 were simulated on exterior side.

4 Experimental results

Typical experimental results are given in Figs. 4-10. We can see that some overhygroscopic moisture was found in the brick wall during the whole time of the experiment, and a part of it remained there until the end of the winter period. However, it should be noted that the conditions of the experiment were more severe than in the reality. In the beginning of the experiment, the brick wall was freshly built in the laboratory, i.e. it contained relatively high amount of moisture and was at relatively high temperature. The climatic conditions of the end of October then have led to water condensation in a part of the wall. This water could not be fully removed from the wall during the winter period because of the limited possibility of water transport to the exterior and of the continuous transport of water vapor from the interior to the load bearing structure increasing the total amount of water in the brick. On the other hand, the capillary active mineral wool material DU remained dry during the whole critical part of the year, which is clearly a consequence of the high values of its moisture transport parameters.

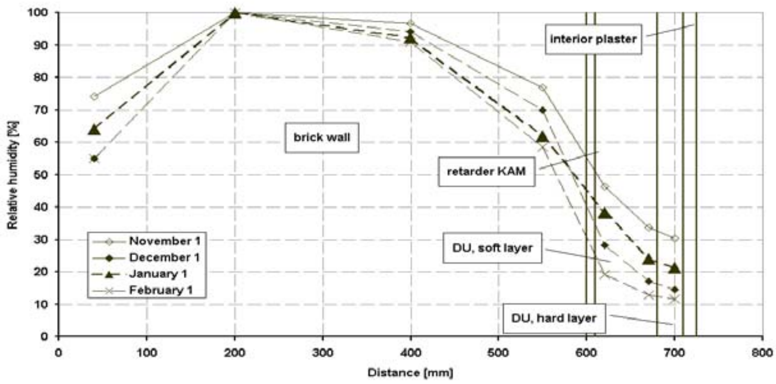

Fig. 4 Relative humidity profiles, section A-A’

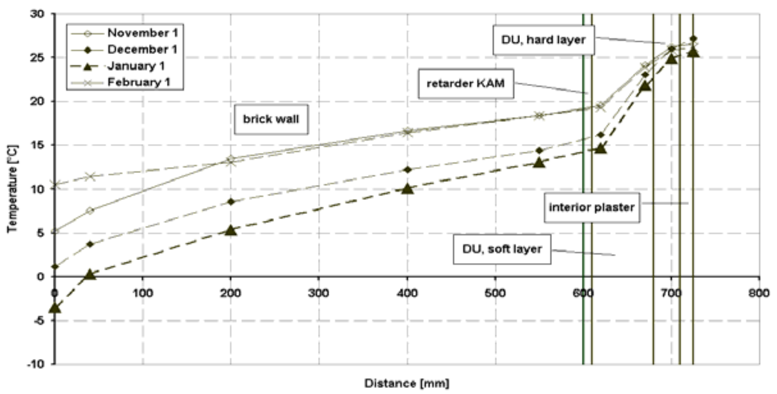

Fig. 5 Temperature profiles, section A-A’

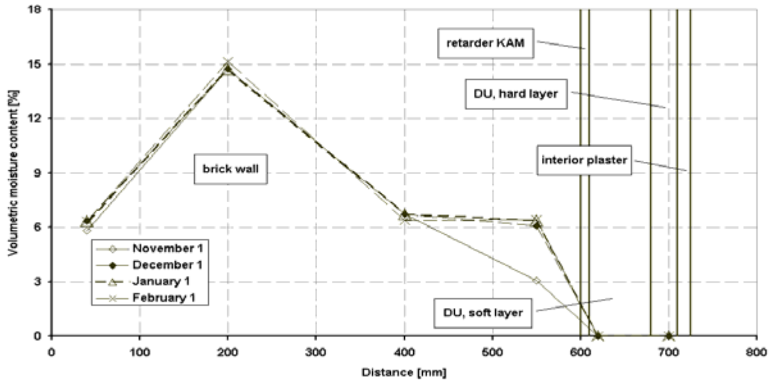

Fig. 6 Volumetric moisture content profiles, section A-A’

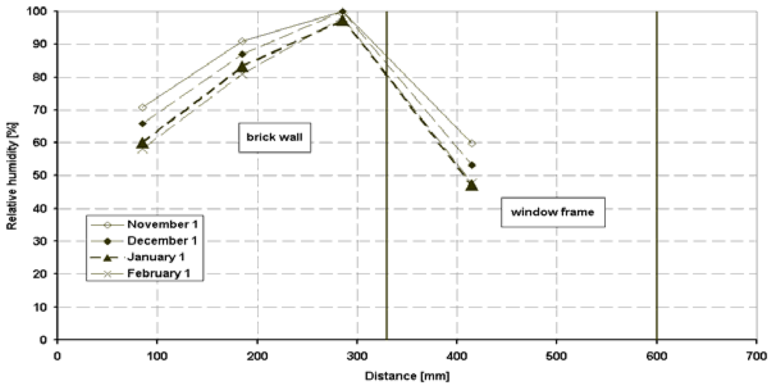

Fig. 7 Relative humidity profiles, section B-B’

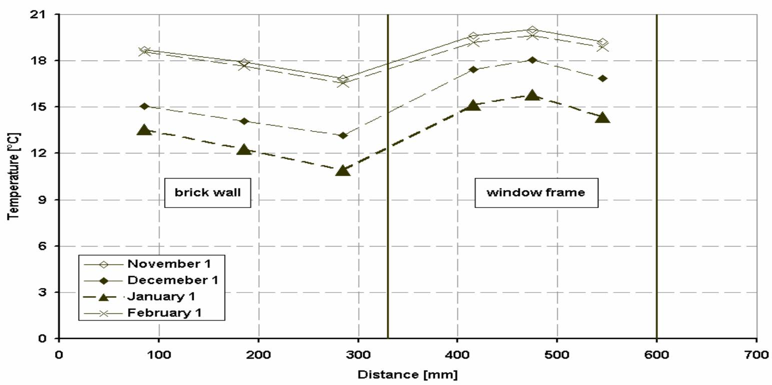

Fig. 8 Temperature profiles, section B-B’

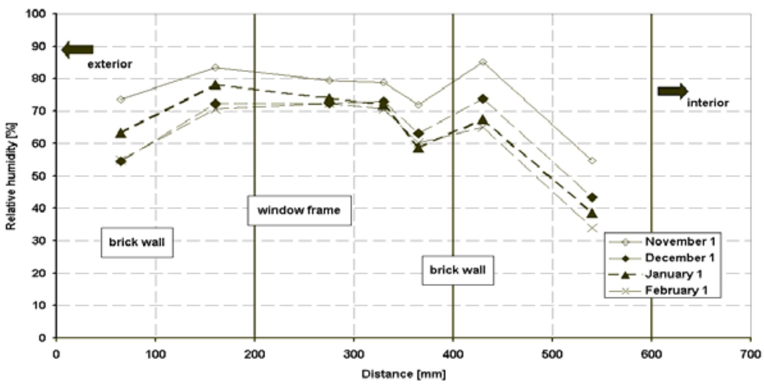

Fig. 9 Relative humidity profiles, section C-C’

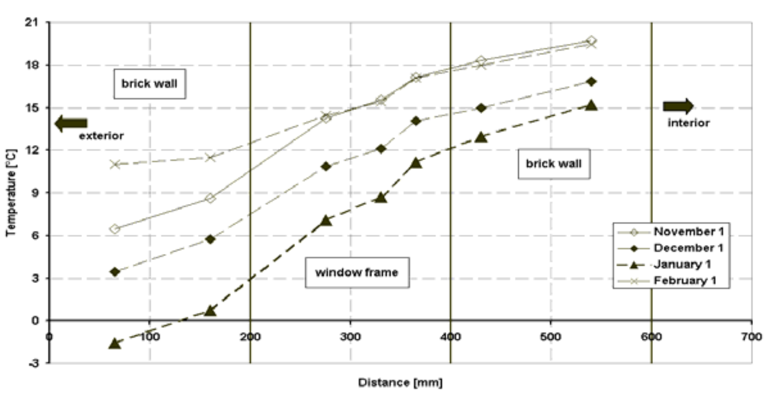

Fig. 10 Temperature profiles, section C-C'

Conclusions

On the basis of the semi-scale experiment, it can be concluded that the analyzed brick wall provided by an interior thermal insulation system with hydrophilic mineral wool insulation and water vapor retarder on the surface of the load bearing structure exhibited a reasonable hygrothermal performance, particularly taking into account that the initial conditions were much worse than in the reality.

Acknowledgement

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References

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