ICMB25

International Conference on Moisture in Buildings (ICMB25), UM Guimarães 23-24 Oct 2025

A36: Experimental assessment of hygrothermal behaviour of historical Hungarian masonry bricks

Fanni Petresevics*[a], Balázs Nagy[a]

a Budapest University of Technology and Economics, Budapest, Hungary

* Corresponding author: petresevics.fanni@emk.bme.hu

How to cite: Petresevics, F., Nagy, B. (2025) Experimental assessment of hygrothermal behaviour of historical Hungarian masonry bricks. In: Abstracts of *the 3rd International Conference on Moisture in Buildings 2025*, 23-24 Oct 2025, Portugal. *UCL Open Environment*: UCL Press; 2025. Pp 1-3. DOI: 10.14324/111.444/ucloe.icmb25.a36

Peer review statement
This abstract has undergone single blind review by the ICMB25 Conference Scientific Committee.

Copyright and open access
©2025 The Authors. Creative Commons Attribution Licence (CC BY) 4.0 International licence
https://creativecommons.org/licenses/by/4.0/

Open access
This is an open access article distributed under the terms of the Creative Commons Attribution Licence (CC BY) 4.0 https://creativecommons.org/licenses/by/4.0/, which permits unrestricted use, distribution and reproduction in any medium, provided the original author and source are credited.

About the conference
The following abstract is from the 3rd International Conference on Moisture in Buildings (https://ukcmb.org/icmb25) held in UM Guimarães, Portugal, on the 23-24 Oct 2025. All abstracts published here underwent single blind review by the Conference Scientific Committee.

Abstract

Hungary's historical masonry building stock, mainly constructed in the 19th and early 20th centuries, features ceramic bricks of diverse quality and unknown hygrothermal characteristics. This study aims to support the energy-efficient renovation and preservation of heritage buildings by providing detailed material characterization of early 20th-century Hungarian bricks. Main physical, hygric, and material properties were analyzed to deepen the understanding of traditional masonry and its performance. The findings contribute to a growing database that will aid future assessments of thermal compliance and renovation planning. Beyond technical aspects, the research highlights the architectural, cultural, and historical significance of these constructions, emphasizing their value and the need for informed conservation strategies aligned with heritage protection goals.

Keywords: building physics; hygrothermal analysis; material composition; masonry bricks, renovation

Nomenclature

ρ_{bulk}	bulk density [kg/m^3]
λ	thermal conductivity [W/mK]
α	thermal diffusivity [m^2/s]
c_p	specific heat capacity [kJ/kgK]

RH	relative humidity [%]
p_{total}	total porosity [-]

1. Introduction/Background

This study provides a comprehensive characterization of early 20th-century Hungarian masonry bricks, focusing on thermal, physical, and hygric properties. Earlier studies have demonstrated that raw material origin and firing processes strongly influence the performance of historical bricks [1,2], which is why this study places special emphasis on comparing historical bricks with modern products to assess differences in material performance. The microstructural and elemental composition was also examined using scanning electron microscopy (SEM) and energy dispersive X-ray spectroscopy (EDS) to support the understanding of hygrothermal behavior and degradation resistance. The primary aim of determining as many characteristic material properties as possible is to enable their accurate interpretation and implementation into hygrothermal simulations, ensuring that the long-term moisture and energy behavior of heritage walls can be reliably modeled. These efforts contribute to a region-specific material database for restoration practices and support heritage preservation through performance-based evaluation. The research also builds on the authors' previous findings on the thermal behavior of historic masonry units [3] and aligns with recent international approaches to microstructural and hygric brick evaluation [4].

2. Experiments and results

Thermal properties were measured on 11 types of historical bricks using the Modified Transient Plane Source (MTPS) method, following a drying process based on MSZ EN ISO 12570:2000. Bulk density (ρ_{bulk}) ranged between 1615 and 1819 kg/m³. Total porosity of the bricks was determined using pycnometry in accordance with EN 1097-6:2022, based on the measured oven-dry and bulk density values. Results showed that total porosity varied between 0,34 and 0,44, confirming significant variability among samples and supporting the observed differences in thermal and moisture-related behavior as seen in Figure 1a. Thermal conductivity (λ) varied from 0,47 to 0,66 W/mK, thermal diffusivity (α) from $2{,}2\times10^{-7}$ to $4{,}0\times10^{-7}$ m²/s, and specific heat capacity (c_p) from 0,81 to 0,97 kJ/kgK. The measurements were performed under laboratory conditions in a climate chamber, and the temperature dependence was investigated between 10-50°C. Results show that thermal conductivity and specific heat increased moderately with temperature, while thermal diffusivity remained relatively stable in historical samples. The correlation coefficient (R^2-value) between bulk density and thermal conductivity and specific heat capacity showed only 0,21-0,28 R^2-value, reflecting internal heterogeneity. These findings highlight the inadequacy of density-based predictions for historical masonry.

Hygrothermal analysis included capillary water absorption tests performed on three samples per brick type following the EN ISO 15148:2002 standard, using partial immersion. Sorption behavior was assessed using adsorption isotherm measurements following MSZ EN ISO 12571:2022, where RH levels were increased from 10% to 95% at 23 °C in 10% increments in a controlled climatic chamber. One small sample per brick was used to ensure comparability. Mass equilibrium at each RH level was confirmed when weight variation dropped below 0.1% between consecutive 24-hour measurements. For verification, salt solution method tests were also conducted on larger specimens at six selected RH levels (9–93%) in a controlled room. The measured sorption isotherms aligned well with existing literature data [5], confirming the reliability of the method. As shown in Figure 1b, the specific moisture content of sample VI-1 reached ~18 kg/m³ at 93% RH in the adsorption phase, and exceeded 30 kg/m³ during desorption, indicating significant hysteresis. For sample VIII-1, adsorption remained under 10 kg/m³, and desorption values were also consistently lower than those of VI-1, demonstrating less pronounced moisture storage and hysteresis. Both materials followed a nonlinear increase in sorbed moisture with RH, particularly above 85% RH, consistent with pore saturation effects. Compared to the standard reference brick defined in MSZ EN 24140:2015, both samples exhibited lower specific moisture content values up to 95% relative humidity. Above this threshold, corresponding to the onset of capillary condensation, both materials absorbed significantly more moisture than the standard curve, indicating a higher capacity for capillary water uptake. These results confirm the moisture-buffering potential of certain historical bricks and their relevance in hygrothermal modelling. The observed hysteresis effects further emphasize the role of pore structure and firing conditions in moisture transport.

Material composition was studied using SEM-EDS, identifying key oxides such as SiO_2, Al_2O_3, Fe_2O_3, and CaO. Bricks with higher CaO and Fe_2O_3 content showed increased density and thermal conductivity, indicating denser microstructures. SEM imagery revealed variation in pore morphology and firing temperature: low-fired samples displayed open, angular pores and loosely bonded grains, while high-fired bricks exhibited partial vitrification and compact structure, consistent with improved thermal transport but reduced moisture uptake.

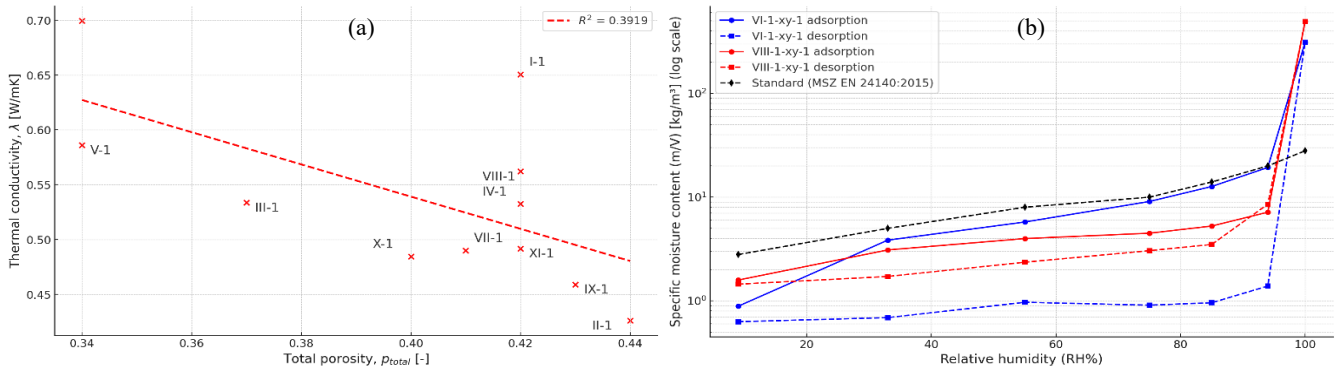

Figure 1. (a) Thermal conductivity as a function of total porosity (at 23°C and 50% RH); (b) Specific moisture content as a function of RH% (at 23°C)

3. Conclusion and future research perspectives

The presented findings provide important data for energy simulations and digital modeling, supporting architects and engineers in making informed decisions during renovations and energy upgrades of both historical and modern buildings, with the aim of developing a comprehensive, type-based database grounded in the measured results. Future work will include additional tests such as water vapor diffusion resistance measurement and mercury intrusion porosimetry (MIP).

References

[1] E. Goemaere et al., "Archaeometric and archaeological characterization of fired clay bricks," ArcheoSciences, vol. 43, pp. 107–132, 2019.
[2] Y. Aït Oumeziane et al., "Hygrothermal properties of early 20th century clay bricks," Constr. Build. Mater., vol. 273, 2021.
[3] F. Petresevics and B. Nagy, "Thermal Properties of Historical Hungarian Masonry Bricks," YBL J. Built Environ., vol. 9, no. 2, pp. 71–84, 2024.
[4] J. Misiewicz et al., "Characterization of Bricks from Baroque Monuments in Northeastern Poland," Materials, vol. 18, no. 13, p. 3023, 2025.
[5] Y. Aït Oumeziane, A. Pierre, F. El Mankibi, V. Lepiller, M. Gasnier, and P. Désévaux, "Hygrothermal properties of an early 20th century clay brick from eastern France: Experimental characterization and numerical modelling," Construction and Building Materials, vol. 273, p. 121763, 202.

Publisher note

The abstracts published in this Supplement have been typeset from electronic submissions and camera-ready copies prepared by the authors. Every effort has been made to reproduce faithfully the abstracts as submitted. These abstracts have been prepared in accordance with the requirements of the International Conference on Moisture in Buildings 2025 and the UK Contre for Moisture in Buildings and have not been subjected to review nor editing by the journal *UCL Open Environment* (published by UCL Press). However, no responsibility is assumed by the organisers or publisher for any injury and/or damage to persons or property as a matter of products liability, negligence or otherwise, or from any use or operation of methods, products, instructions or ideas contained in the material herein.