A12: Hygrothermal performance of heritage masonry retrofitted with lime hemp interior insulation: a monitoring campaign

Evy Vereecken[a,b,*], Staf Roels[a], Marc Stappers[c]

[a]*KU Leuven, Department of Civil Engineering, Section of Building Physics and Sustainable Design, Heverlee (Leuven), Belgium*
[b]*Royal Institute for Cultural Heritage (KIK-IRPA), Monuments and Monumental Decoration Lab, Brussels, Belgium*
[c]*Cultural Heritage Agency, The Netherlands*

* Corresponding author: evy.vereecken@kuleuven.be

How to cite: Vereecken, E., Roels, S., Stapper, M. (2025) Hygrothermal performance of heritage masonry retrofitted with lime hemp interior insulation: a monitoring campaign. 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.a12

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

This study presents the monitoring results for solid masonry internally insulated with lime hemp blocks in combination with loose lime hemp filling. A drying out of the moisture in the loose lime hemp is found to occur very slowly. The high moisture conditions in the lime hemp together with a reduced actual insulation thickness of the lime hemp blocks, due to a.o. the penetration of the interior plaster in the insulation blocks, yields a rather low improvement of the walls' thermal performance.

Keywords: interior insulation; monitoring campaign; hygrothermal performance; lime hemp; heritage masonry

1. Introduction

The application of interior insulation is frequently considered for enhancing the energy efficiency of and the thermal comfort in historic buildings. Unfortunately, although often the only option, this post-insulation technique involves a risk on several (often moisture-related) damage patterns, such as interstitial condensation, frost damage and mould growth [1], which often leads to a certain caution for their application. The last decades, several new types of (biobased) interior insulation systems have been developed, and these are often presented as interesting systems to reduce possible risks [2]. However, more knowledge is still needed to accurately estimate the hygrothermal response of these new interior insulation systems and their actual risks, and hence to fully utilize their potential in our efforts to lower the carbon footprint of historic buildings without introducing damage.

Therefore, this study shows the results of a monitoring campaign conducted in the framework of the research project 'Energy Performance of Solid Brick Walls in Residential Heritage Buildings', subsidized by the Cultural Heritage Agency of the Netherlands.

2. Field study

The current study presents the monitoring results of two housing units, i.e. "Melkhuis" and "Vijverhuis", of the building estate "Grote Noordijk" in Wilp, the Netherlands (Figure 1a). The exterior walls of "Melkhuis" and "Vijverhuis" are solid masonry walls of 21 cm thick, constructed with ceramic bricks with a capillary absorption coefficient equal to approximately 0.35 kg/m^{2}s$^{0.5}$ (for the south- and west-oriented walls) and 0.3 kg/m^{2}s$^{0.5}$ (for the north-oriented wall). In November 2022, the masonry walls were insulated with lime hemp on the interior side. Lime hemp blocks with a thickness of 9 cm were positioned at a distance of 3 cm from the original wall, after which the cavity between masonry and lime hemp blocks was filled up with loose lime hemp. A 1 cm thick interior finishing plaster was applied, which was absorbed by the lime hemp over a thickness of 0.5 cm approximately.

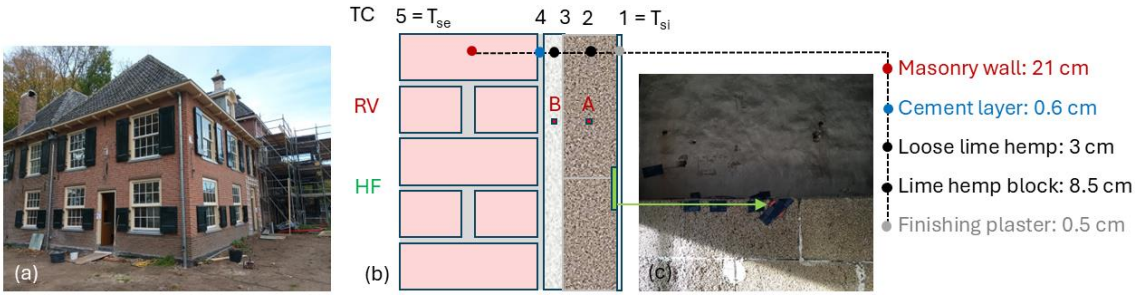

Figure 1. (a) Field study "Grote Noordijk" in Wilp, The Netherlands; (b) wall composition with a indication of the sensor positions; (c) heat flux meter placed on the lime hemp blocks.

Before the renovation, a cement finishing was present at the masonry's interior surface. Though this cement finishing was (partially) removed in 2021 to accelerate the drying of the (potentially due to rising damp) moist walls, the cement layer was still present at the monitored locations with interior insulation (Figure 1c). Hence, the effective composition of the analysed walls is as shown in Figure 1b. To monitor the walls' hygrothermal performance, temperature and relative humidity sensors as well as heat flux meters were installed (Figure 1b). Both south-, west-, and north-oriented walls were monitored, allowing to analyse the impact of wind-driven rain. The monitoring of the renovated test cases started at November 11th, 2022.

3. Results

Figure 2 presents the relative humidity monitored in the lime hemp blocks (location A) and in the loose lime hemp (location B) as a function of time. In the first five months after applying the lime hemp interior insulation, the relative humidity in the loose lime hemp remains above 80% relative humidity, and this for the three orientations. Hereafter, the relative humidity shows a clear decrease for the north-oriented wall, whereas for the south- and west-oriented wall with a higher wind-driven rain exposure, the relative humidity stays between 80 and 85% for another two months. Overall, the moisture conditions in the lime hemp interior insulation remain rather high, and this despite the unoccupied state of the monitored rooms, which results in a lower indoor vapour pressure, and which might entail a higher inward drying potential and a lower risk on interior condensation.

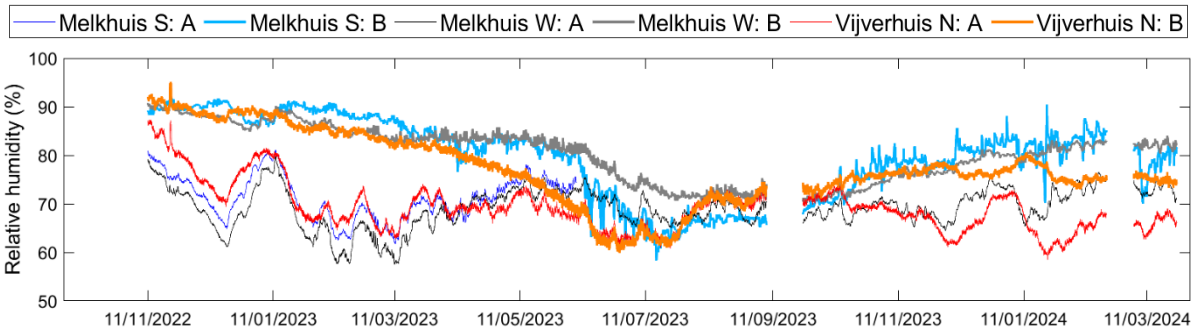

Figure 2. Relative humidity monitored at Location 'A' and 'B' (see Figure 1b for the location). The sensor in the lime hemp blocks in the south-oriented wall is broken since June 7, 2023.

The rather high relative humidity, and thus high moisture content, in the lime hemp insulation has a negative impact on the thermal resistance and thus thermal upgrade achieved by this renovation measure. This is clearly visible in the monitoring data. A short measurement campaign before the renovation resulted in a R_c-value equal to 0.38 m^2K/W for the non-insulated north-oriented wall, which is in line with the theoretical calculation based on the brick's thermal conductivity. After the renovation, this R_c-value only increased to 1.2 m^2K/W, and this while the theoretical R_c-value for just the insulation layer is around 1.5 m^2K/W. Additional reasons for this limited increase can be found in the - compared to the info in the technical data sheet - slightly lower thickness of the lime hemp blocks and the additional reduction in thickness due to the penetration of the interior plaster in the blocks.

4. Conclusion and discussion

The results of a 1.5-year field measurement on a masonry building insulated with lime hemp interior insulation have been shown. A high relative humidity in the loose lime hemp, especially for the walls exposed to wind-driven rain, was found. Drying out of the moisture in the loose lime hemp occurs very slowly. This high moisture content of the lime hemp has a negative impact on the achieved thermal improvement. As the current study focuses on a single case study, the results might not be generalized. However, the results show that caution is recommended when dealing with one-stone-thick masonry exposed to wind-driven rain.

References

[1] Vereecken, E., Van Gelder, L., Janssen, H., & Roels, S. (2015). Interior insulation for wall retrofitting – A probabilistic analysis of energy savings and hygrothermal risks. *Energy and Buildings 89*, 231-215.
[2] Claude, S., Ginestet, S., Bonhomme, M., & Escadeillas, G. (2020). Performance of bio-based insulation materials in an old building envelope system. In "Bio-based materials and biotechnologies for eco-efficient construction", Woodhead Publishing Series in Civil and Structural Engineering, p. 105-128.

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.