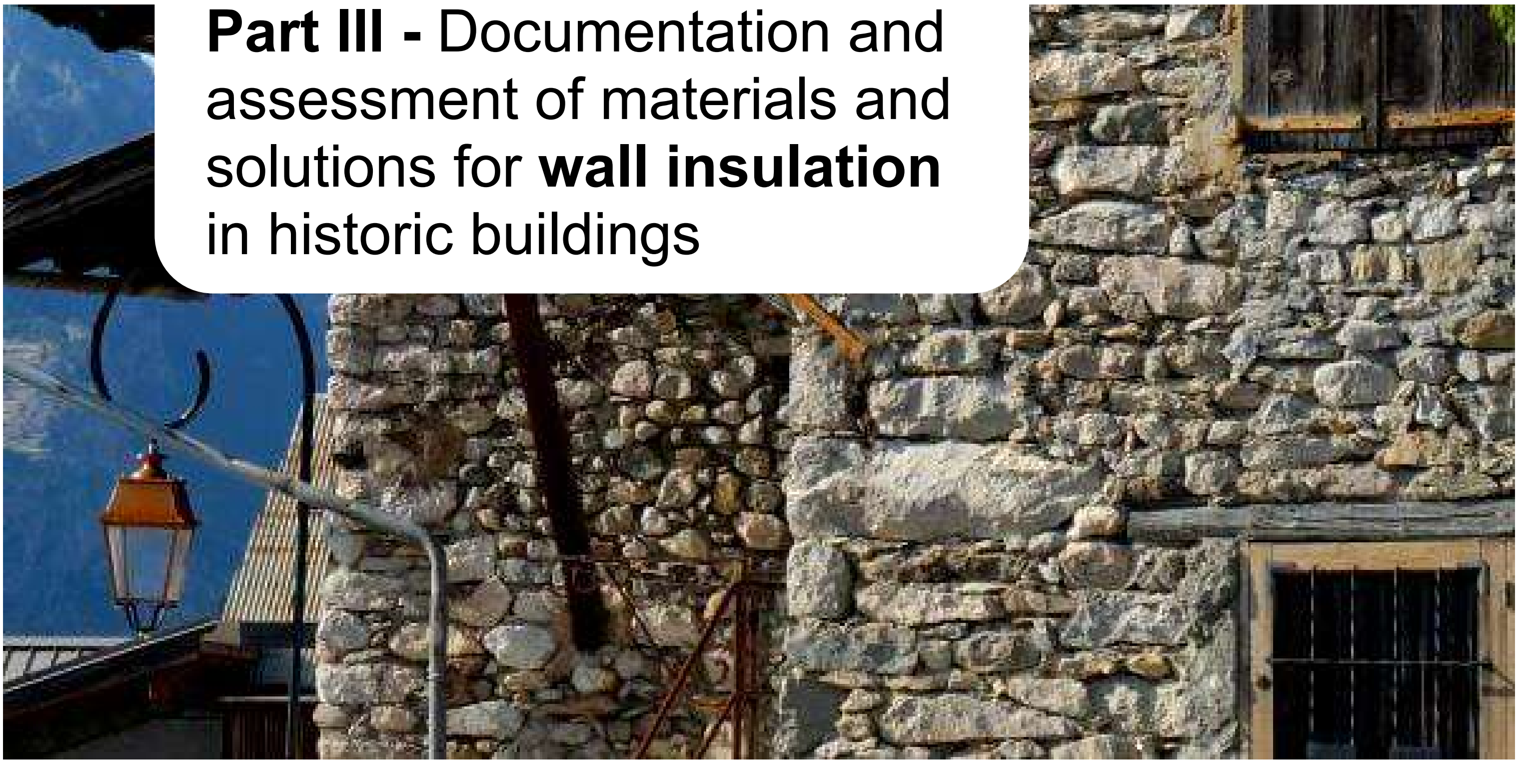
SOLAR HEATING & COOLING PROGRAMME
INTERNATIONAL ENERGY AGENCY

Conservation compatible energy retrofit technologies

Part III - Documentation and assessment of materials and solutions for **wall insulation** in historic buildings



IEA SHC Task 59 | EBC Annex 76
Renovating Historic Buildings Towards Zero Energy

Conservation compatible energy retrofit technologies

Part III: Documentation and assessment of materials and solutions for **wall insulation** in historic buildings

Editors: Rainer Pfluger (UIBK), Alexander Rieser (UIBK)

Contributing authors: Eleonora Leonardi (EURAC), Daniel Herrera (EURAC), Ernst Jan de Place Hansen (AAU), Roger Curtis (HES), Valentina Marincioni (UCL), Athina Petsou (UCL), Evola Gianpiero (UNICT), Cristina Polo (SUPSI), Sara Mauri (POLIMI), Tobias Hatt (EIV), Gustaf Leijonhufvud (Uppsala University), Susanne Kuchar (e7 energy innovation & engineering), Pavel Sevela (UIBK), Julien Borderon (Cerema)

October 2021

SHC Task 59 | EBC Annex 76 | Report D.C1-III

DOI: 10.18777/ieashc-task59-2021-0006

IEA SHC Task 59 | EBC Annex 76: Deep renovation of historic buildings towards lowest possible energy demand and CO_2 emission (NZEB)

Solar Heating and Cooling Technology Collaboration Programme (IEA SHC)

The Solar Heating and Cooling Technology Collaboration Programme was founded in 1977 as one of the first multilateral technology initiatives (*"*Implementing Agreements*"*) of the International Energy Agency.

Our mission is *"Through multi-disciplinary international collaborative research and knowledge exchange, as well as market and policy recommendations, the IEA SHC will work to increase the deployment rate of solar heating and cooling systems by breaking down the technical and non-technical barriers."*

IEA SHC members carry out cooperative research, development, demonstrations, and exchanges of information through Tasks (projects) on solar heating and cooling components and systems and their application to advance the deployment and research and development activities in the field of solar heating and cooling.

Our focus areas, with the associated Tasks in parenthesis, include:

- Solar Space Heating and Water Heating (Tasks 14, 19, 26, 44, 54)
- Solar Cooling (Tasks 25, 38, 48, 53, 65)
- Solar Heat for Industrial and Agricultural Processes (Tasks 29, 33, 49, 62, 64)
- Solar District Heating (Tasks 7, 45, 55)
- Solar Buildings/Architecture/Urban Planning (Tasks 8, 11, 12, 13, 20, 22, 23, 28, 37, 40, 41, 47, 51, 52, 56, 59, 63, 66)
- Solar Thermal & PV (Tasks 16, 35, 60)
- Daylighting/Lighting (Tasks 21, 31, 50, 61)
- Materials/Components for Solar Heating and Cooling (Tasks 2, 3, 6, 10, 18, 27, 39)
- Standards, Certification, and Test Methods (Tasks 14, 24, 34, 43, 57)
- Resource Assessment (Tasks 1, 4, 5, 9, 17, 36, 46)
- Storage of Solar Heat (Tasks 7, 32, 42, 58, 67)

In addition to our Task work, other activities of the IEA SHC include our:

- SHC Solar Academy
- *Solar Heat Worldwide*, annual statics report
- SHC International Conference

Our members

Australia	European Copper Institute	SICREEE
Austria	France	Slovakia
Belgium	Germany	South Africa
Canada	International Solar Energy Society	Spain
CCREEE	Italy	Sweden
China	Netherlands	Switzerland
Denmark	Norway	Turkey
EACREEE	Portugal	United Kingdom
ECREEE	RCREEE	
European Commission	SACREEE	

For more information on the IEA SHC work, including many free publications, please visit www.IEA SHC.org.

Energy in Buildings and Communities Technology Collaboration Programme (IEA EBC)

To reach the objectives of SHC Task 59 the IEA SHC implementing Agreement has collaborated with the IEA EBC Implementing Agreement at a "Medium Level Collaboration", and with the IEA PVPS Implementing Agreement at a "Minimum Level Collaboration" as outlined in the SHC Implementing Agreement's Policy on Collaboration.

Contents

2.2.4 Innovative system solutions

2.2.4.1 Aerogel – based textile wallpaper – La Nave, Italy

Author: Sara Mauri (Polimi)

What is the solution?

The solution is a super-insulating aerogel-based textile wallpaper that can be installed on the inner side of the perimeter walls. The innovative wallpaper is based on two completely independent layers with an air gap of about 2 mm in between, combining properties of advanced technical textiles and high-performance insulating materials in few mm of thickness. The system is composed of a layer made of a porous, flexible support impregnated with silica aerogel glued to the existing wall, forming the insulating core, and a finishing textile layer. The latter can be easily installed and replaced thanks to a simple tensioning device, consisting of a system of plastic zips fixed to the wall on one side and connected to the finishing layer on the other side. The top connection, fixed to the wall with nails and/or glue, is based on a PVC strip carrying a plastic zip with a slider on one edge. At the bottom of the wall, the plastic zips are applied on the finishing textile by means of a thermo-adhesive tape that is ironed on the fabric. The wallpaper system was developed by Politecnico di Milano (professors C. Monticelli, A. Zanelli, S. Aliprandi, G. Masera) within the European project EASEE (Envelope Approach to improve Sustainability and Energy efficiency in Existing multi-storey multi-owner residential buildings), Patent n. WO201781568 "Functional upholstery system, method for installation of such upholstery, installation kit of such upholstery Images" Inventors - Monticelli Carol, Zanelli Alessandra, Masera Gabriele, Aliprandi Stefano.

Why does it work?

The textile wallpaper is characterized by ease of assembly/disassembly for periodic use, flexibility, reversibility, not destructiveness, lightness, small thickness and meets the intervention requirements of historic buildings. This system represents a technological improvement of a tapestry, a solution coming from the past and traditionally used to mitigate the effects of the lower wall temperatures. The improvement due to the textile is valuable, considering the number of square meters that could reduce the thermal exchange with the colder surface underneath. The thermal performance of the new wallpaper was compared to other two internal thermal insulation systems, traditional in terms of installation process: they are wet assembled, thicker than the new textile wallpaper and not reversible (advanced insulated perlite board; laminated panel composed of silica aerogel impregnated unwoven fibrous blankets fixed to a rigid support). The results of the tests showed that the performance of the textile wallpaper is comparable with the one of the interior traditional insulation. The insulating layer that composed the system presents the following thermal characteristics: average thermal resistance R = 0,125 m^2K/W; thermal conductivity λ = 0,036 W/(mK). Moreover, the solution was defined "permeable insulating wallpaper" because it is open to water vapour diffusion, a crucial aspect from the point of view of building physics.

Description of the context

This inner retrofitting system was installed on a test wall that is part of an eight-storey building called "La Nave" (building n°14), situated at the Leonardo University Campus of Politecnico di Milano. The building was designed by Gio Ponti, a famous architect active from the 1920sto the 1970s, and hosts classrooms and teachers' offices. It was built in 1965 and classified as Cultural Heritage in 2007. "La Nave" is characterised by a concrete and steel structure and the façade is an unventilated cavity wall. From outside to inside, the wall is composed of: vitrified grey ceramic tiles (dimensions: 15x7,5x0,7 cm), cement base render (2,5 cm), first layer of hollow bricks (12 cm thick), an unventilated air cavity (34,5 cm thick), second layer of hollow bricks (8 cm thick) and internal cement lime-based plaster with gypsum finishing (1,5 cm). The whole thickness of the wall before retrofit is 59.2 cm. It is a typical massive construction with low level of thermal insulation, as many constructions of that time. The portion of the wall retrofitted is placed at the second floor, South-East and South-West oriented and belongs to a meeting/teaching room. The inner surface covered by the wallpaper system is 3,37 m^2, with a 7 mm thickness. The insulation layer was glued to the existing wall with a breathable mineral mortar and the finishing layer was then applied in front of the insulation with a bespoken tensioning system.

Pros and Cons

Pros: low thermal conductivity (λ= 0.036 W/(mK)); thin and lightweight solution; controlled fire behaviour; water vapour permeability; mitigates the effect of the cold surface of the wall; ease of transportation and storage; ease of installation because all the assembly operations can be performed with common tools (scissors, cutter, hammer and flatiron); insulation layer glued to the existing wall like a standard wallpaper; finishing layer completely dry-assembled and removable for any reason (like washing, substituting a failing element, improving the performances or simply changing the appearance of the wall); geometrical adaptability which allows the application on (not always planar) existing walls, following their forms also in correspondence of the corners, thanks to the physical flexibility of all the components.

Cons: applicable only as indoor insulation solution; the use in historic buildings may be restricted due to existing important decorations (i.e. wall paintings); high costs of the aerogel material.

Type of Data Available

The aerogel insulating layer was tested and characterized at laboratory scale to ensure its high thermal performance and its permeability. The whole wallpaper system was then monitored on-site and simulated through a Heat and Moisture Transfer modelling. This study was carried out both before and after the retrofit. The insulating layer was tested in laboratory following the directives of the reference standards in order to have complete data to describe its behaviour. The measured properties are: density by means of volume and weight; thermal conductivity in dry and moist conditions (EN 12667 and EN 12664); water vapour transmission properties (EN ISO 12572); hygroscopic absorption properties (EN ISO 12571); long-term water absorption by total immersion (EN 12087). A continuous monitoring campaign has been carried out from December 2013 until March 2015, including seven months before retrofit and eight months after retrofit (July 2014). The system was monitored by means of temperature, moisture and heat flux probes. Finally, the hygro-thermal behaviour of the base wall and the retrofitted one have been assessed in transient conditions by means of the software WUFI Pro 5.3.

Is there any related publication?

- Galliano R., Ghazi Wakili K., Binder B., Daniotti B., *Evaluation of three different retrofit solutions applied to the internal surface of a protected cavity wall*, in Energy Procedia, 2015, 78, pp. 848-853.
- Galliano R., Ghazi Wakili K., Stahl Th., Binder B., Daniotti B., *Performance evaluation of aerogel-based and perlite-based prototyped insulations for internal thermal retrofitting: HMT model validation by monitoring at demo scale*, in Energy and Buildings, 2016, 126, pp. 275-286.
- Masera G., Ghazi Wakili K., Stahl T., Brunner S., Galliano R., Monticelli C., Aliprandi S., Zanelli A., Elesawy A., *Development of a super-insulating, aerogel-based textile wallpaper for the indoor energy retrofit of existing residential buildings*, in Procedia Engineering, 2017, 180, pp. 1139-1149.
- Monticelli C., Zanelli A., Aliprandi S., Pracchi V. N., Rosina E., *The energy efficiency improvement of listed buildings through textile-based innovative system*, in Advanced Building Skins, Berna, Switzerland, 10-11 October 2016, pp. 192-202.
- Pracchi V., Rosina E., L’Erario A., Monticelli C., Aliprandi S., Zanelli A., *From arazzo to textile based innovative system for energy efficiency of listed buildings*, in Conference Proceedings of the 3rd International Conference on Preservation, Maintenance and Rehabilitation of Historical Buildings and Structures Heritage 2017, ed by R. Amoeda, S. Lira, C. Pinheiro, Green Lines Institute for Sustainable Development Braga, Portugal, 14-16 June 2017, pp. 1093-1103.
- Pracchi V., Rosina E., Zanelli A., Monticelli C., *Removable textile devices to improve the energy efficiency of historic buildings*, in Conference Proceedings of the 3rd International Conference on Energy Efficiency in Historic Buildings, ed by T. Broström, L. Nilsen, Visby, Sweden, 26-27 September 2018, pp. 127-134.

Additional Link

https://patentscope.wipo.int/search/en/detail.jsf?docId=WO2017081568&tab=PCTBIBLIO

figure 89: Details of the wallpaper system, ©Polimi

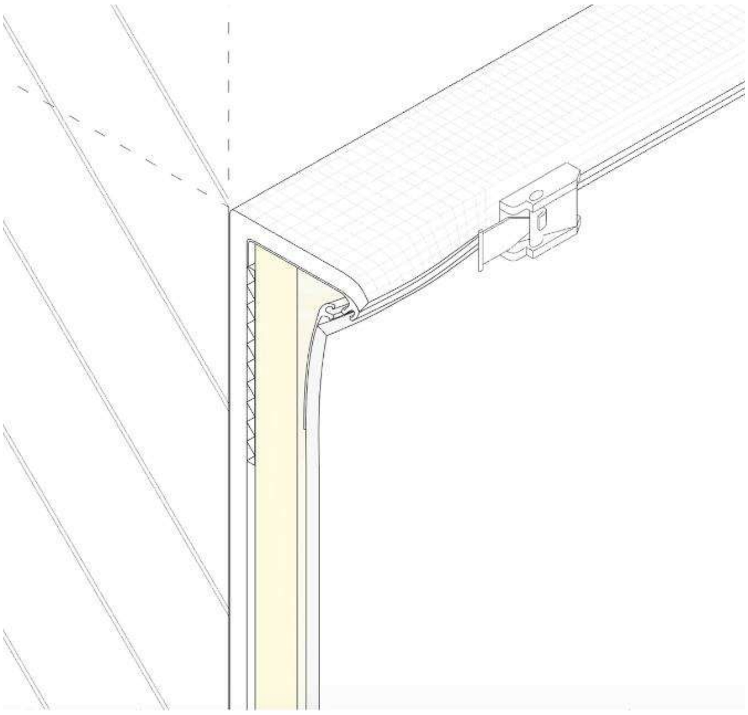


figure 90:*: Axonometric projection of the top connection, ©Polimi*

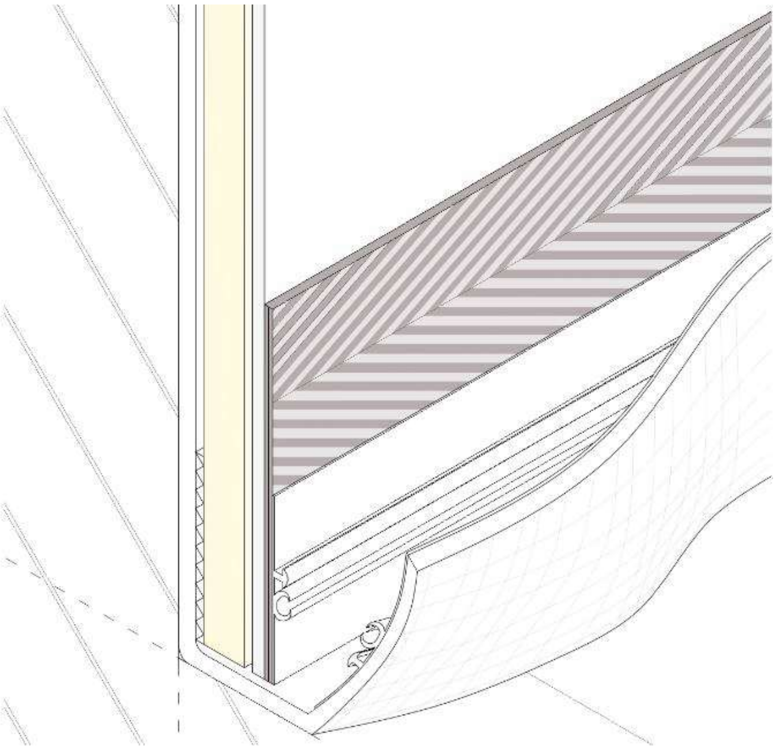


figure 91:*: Axonometric projection of the bottom connection, ©Polimi*