

A9: Effects of accelerated ageing on the long-term thermal conductivity of thermal insulating mortars

João L. Parracha^{a,b,*}, Léo Pinchard^{a,c}, Luís Matias^a, Rosário Veiga^a

^aLNEC, National Laboratory for Civil Engineering, Lisbon, Portugal

^bCERIS, Instituto Superior Técnico, University of Lisbon, Lisbon, Portugal

^cÉcole Centrale de Lyon, Lyon, France

* Corresponding author: jparracha@lnec.pt

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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

Thermal insulating mortars have been widely used in building facades, thus improving the thermal performance of the building envelope. However, reliable data on their long-term thermal performance is still lacking. The aim of this work is to evaluate the long-term thermal conductivity of industrially produced and experimentally designed thermal mortars with EPS, cork and silica aerogel aggregates. The long-term performance of the mortars was assessed prior, during and after exposure to three accelerated ageing tests including elevated temperature, freeze-thaw and high humidity levels. For each test, an empirical model was used to compute the acceleration factor, correlating accelerated and natural ageing. The results show that a maximum increase of thermal conductivity up to 30% can be obtained after ageing.

Keywords: Thermal insulation materials; Durability assessment; Thermal performance

1. Introduction

Thermal mortars are currently being used for enhancing the thermal performance of the building envelope in both new construction and retrofitting of facades. The general principle of a thermal mortar formulation is to replace a volume of conventional aggregates (e.g., sand) with lightweight aggregates presenting lower thermal conductivity. Among the most commonly used materials are expanded polystyrene, expanded clay, expanded cork,

silica aerogel, perlite or expanded glass. The incorporation of these aggregates in sufficient quantities allows to obtain a mortar with enhanced thermal performance compared to a conventional mortar.

Mortars' long-term thermal performance can be affected due to the ageing of the material, caused by the possible synergistic effect of several degradation agents over time (e.g., moisture, extreme temperatures, solar radiation, pollution or biological colonization). Nevertheless, reliable data on their long-term thermal performance is still lacking. Therefore, this work aims at evaluating the long-term thermal conductivity of thermal mortars with EPS, cork and silica aerogel aggregates. The long-term performance was assessed prior, during and after exposure to three accelerated ageing tests including elevated temperature, freeze-thaw and high humidity levels. For each test, an empirical model (i.e., Arrhenius law, Peck model, and Coffin-Manson equation) was used to compute the acceleration factor, correlating accelerated to 10 years of natural exposure.

2. Materials and methods

Four thermal mortars were tested: (i) an industrially produced mortar with silica aerogel aggregates (AER); (ii) a commercially available mortar with EPS aggregates (EPS); (iii) an experimentally designed mortar with natural hydraulic lime 3.5 (NHL 3.5) as binder and sand and cork aggregates (COR); and (iv) a reference NHL 3.5 and sand mortar without lightweight aggregates.

Accelerated ageing methods were used to allow for the assessment of the long-term properties of the mortars. The acceleration of the degradation was obtained by exposing the specimens to intense climatic conditions with respect to those that naturally occur in the geographical area of reference (Lisbon, Portugal). For each mechanism, an empirical law was used to calculate the acceleration factor, assuming a correlation to 10 years of ageing in outdoor natural conditions.

The acceleration factor for the elevated temperature ageing was calculated using the Arrhenius law [1]. The specimens were placed in a mechanical convection oven at a constant temperature of 70 °C. An acceleration factor of 84 was obtained, thus indicating a required exposure time of 43 days in elevated temperature ageing to be equivalent to 10 years of outdoor natural ageing.

The acceleration factor for the high moisture ageing was calculated using the Peck model [2]. The specimens were placed in a climatic chamber with constant humidity (80%) and temperature (60 °C). An acceleration factor of 56 was obtained, thus indicating a required exposure time of 65 days in high moisture content ageing to be equivalent to 10 years of outdoor natural ageing.

The acceleration factor for the freeze-thaw ageing was calculated with the Coffin-Manson equation [3]. The specimens were alternatively placed in an oven at 60 °C and a freezer at -15 °C. An acceleration factor of 270 was obtained, thus indicating a required exposure time of 14 days to be equivalent to 10 years of exposure.

Thermal conductivity measurements were carried out using the heat flow meter steady-state method, according to EN 12667:2001 [4]. To monitor the long-term behavior of the mortars, measurements were performed prior, during and after the ageing procedures. Therefore, two intermediate measurements were performed for each test, at approximately one third and two thirds of their duration. The equation of ISO 10456:2007 [5] was used to account for the effect of humidity and temperature variations in the results.

3. Results and discussion

The thermal conductivity results obtained before and after accelerated ageing are presented in Table 1. The industrially produced mortars (AER and EPS) showed an overall improved ageing performance when compared to the mortars designed in the laboratory (COR and REF), although with remarkably different trends.

The thermal conductivity of AER did not increase by more than 10%, regardless of the type of ageing. It can thus be concluded that this mortar retains good thermal performance after ageing, if compared to commonly used thermal insulation materials in unaged conditions (e.g., EPS boards, with a thermal conductivity of ~ 0.0370 W/(m.K)). On the other hand, mortar EPS only showed a loss of performance in elevated temperature ageing, with a maximum increase of 10% of thermal conductivity, which was possibly related to the degradation of the aggregates. For the other ageing procedures, the thermal conductivity of this mortar followed a significant downward trend, falling by up to 28%. This behavior was explained by a significant increase in porosity of EPS mortars due to the dissolution and leaching of CH and CSH crystals during ageing [6].

Table 1. Thermal conductivity results obtained before and after accelerated ageing.

Accelerated ageing procedure			Natural ageing [years]	Thermal conductivity [W/(m.K)]			
Days	Ageing [%]			AER	EPS	COR	REF

Elevated temperature	0	0	0	0.0320	0.0563	0.219	0.447
	14	33	3	0.0341	0.0621	0.262	0.548
	29	66	7	0.0345	0.0607	-	0.577
	43	100	10	0.0346	0.0606	-	-
High moisture	0	0	0	0.0338	0.0546	0.218	0.419
	22	33	3	0.0363	0.0485	0.224	0.426
	43	66	7	0.0370	0.0430	-	0.427
	65	100	10	0.0371	0.0393	-	0.482
Freeze-thaw	0	0	0	0.0314	0.0523	0.194	0.412
	5	33	3	0.0335	0.0431	-	0.504
	9	66	7	0.0338	0.0413	0.210	0.505
	14	100	10	0.0339	0.0408	0.214	0.505

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