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Inter-laboratory variability results of porous building materials hygrothermal properties

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HIGHLIGHTS

- Simulation programs for building materials performance require material properties.
- Properties used in different models, its availability and reliability are analysed.
- Laboratory tests to determine some hygrothermal properties of a lime natural stone and a lime mortar were developed.
- Some of these tests were performed by two laboratories.
- Tests made by different laboratories are homogeneous for homogeneous materials.
- Test specimen dimensions influences vapour diffusion resistance factor.

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ABSTRACT

The knowledge of material properties to predict heat and moisture transport in buildings is essential to well characterize their behavior and predict pathologies. Nowadays it is quite common the use of hygrothermal simulation programs to predict building materials and components hygrothermal performance and those programs need, as inputs, the material properties.

Bearing this in mind this study is focused on the analysis and discussion of properties used in different models, its availability and reliability. Laboratory test results to determine some hygrothermal properties of two common materials in walls of historical buildings: a lime natural stone and a lime mortar were developed. Some of these tests were performed by two laboratories involved in a project and the main idea is to present and compare the obtained results also comparing with database values.

1. Introduction

Calculation programs that use numerical methods are essential instruments to perform a multitude of calculations in different fields (structural calculations, thermal calculations, acoustic calculations, etc.). Nowadays, it is quite common the use of hygrothermal simulation programs to predict building materials and components hygrothermal performance and those programs need, as inputs, the material properties [1]. The absorption and drying processes in walls are basically governed by heat and moisture transfer. Since 1950 several models based on fluid mechanics were developed using basic laws to simulate heat and moisture transfer (Darcy's law, Fick's diffusion laws, Fourier's law, etc.), but Luikov and Philip-De Vries were the firsts to consider simultaneously these two movements. Later, several software's in 1D and 2D were developed [2,3].

A research, at the end of 2007, found 57 existing hygrothermal simulation models that can be applied in the analysis of moisture transport in building components [4]. The majority has the capacity of analyzing transient conditions problems. Modelling physical transport processes implies a certain degree of simplifications of reality; depending on how detailed the solution is intended [5,6].

The programs available for the general public were 14 and are presented in Table 1, including the input material properties that are needed. In grey are underlined some selected properties that will be analyzed and compared by the two different laboratories.

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Table 1
Programs available for the general public.

Name	Material Properties													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1D-Ham	X		X	X	X	X							X	
BSim2000	X	X	X	X	X	X						X		X
DELPHIN 5	X	X	X	X	X		X	X	X		X		X	
EMPTIED	X		X	X		X		X					X	
GLASTA	X		X	X		X	X							
HygIRC-1D	X		X	X	X	X		X	X				X	
HAMLab	X		X	X			X			X		X		
HAM-Tools	X	X	X	X	X	X		X			X		X	
IDA-ICE	X		X	X	X	X						X	X	
MATCH	X	X	X	X	X	X		X			X	X		X
MOIST	X		X	X	X	X		X	X				X	
MOIST-EXP.	X	X	X	X	X	X		X	X		X	X	X	
UMIDUS	X	X	X	X	X		X							
WUFI	X	X	X	X	X	X			X	X	X	X		

1- Bulk density
2- Porosity
3- Specific heat capacity
4- Thermal conductivity
5- Sorption isotherm
6- Vapor permeability
7- Vapor diffusivity
8- Suction pressure
9- Liquid diffusivity
10- Diffusion resistance factor
11- Water conductivity
12- Specific moisture capacity
13- Air permeability
14- Hysteresis in sorption isotherm

Those properties are commonly used in the most part of the presented programs [7,8].

Recently, some research works have been published about hygroscopic properties of currently building materials. Del Coz Díaz et al., 2013 [9], developed a new experimental procedure for the calculation of the hygroscopic sorption isotherm curves and applied it to the study of the hygroscopic properties of three different LWC. Del Coz Díaz et al., 2014 [10] present the development of a new hybrid methodology to study the moisture transport and heat transfer in masonry structures made up of light concrete hollow bricks (LWHBs) from the numerical and experimental points of view. Other study developed assesses the variability of the water vapour desorption isotherm of concrete under site conditions [11]. "Desorption experiments were carried out on samples of concrete mixtures. Three theoretical models, used to provide physical descriptions of the measured desorption isotherms, were compared. It was found that a Gaussian law can be used to model variability of the desorption isotherm due to in situ hazards". "The water vapour adsorption desorption isotherm and the water vapour permeability of cementitious materials were experimentally evaluated in this study according to the evolving nature of the microstructure of this type of material due to their hardening over time (7 days and 28 days)" [12]. As it is essential to perform an exhaustive campaign of laboratory tests in order to characterize the most common materials in our buildings to obtain the main physical and hygrothermal properties which have to be considered in numerical models, several hygrothermal properties were determined: bulk density, open porosity, specific heat capacity, hygroscopic curves, water vapour diffusion resistance factor, water absorption coefficient and thermal conductivity. Some of these laboratory tests were performed in comparison and contrast between the two laboratories involved in the project.