MODELING MOISTURE TRANSFER OF MORTAR SUBMITED TO CONVECTIVE DRYING

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ABSTRACT

- *This work reports the results of an experimental study concerning the drying of cement mortar and specially the mechanism of moisture transfer during the process.*
- *The effect of the mix-composition, in particular the water-to-cement ratios (W/C), on the microstructure and transfer parameters is investigated.*
- *The experimental campaign aims to characterize from textural and hydric point of views, the materials, by mean of DVS (dynamic vapor sorption). This technique allows to obtain desorption-adsorption cycles and to identify the moisture diffusivity coefficient of mortar for a broad range of relative humidity.*
- *The results show a small dependence on W/C ratio but there is a clear difference between absorption and desorption branches.*
- *Moisture diffusivity in liquid state and in the vapour one was also determined from sorption experiments.*

INTRODUCTION

Drying plays a major part in many industrial sectors as a way to conserve the matter, to reduce the volume of bulky materials, or to finalize the manufacture of a product after a processing under wet conditions. This is why drying investigations concern so many materials, like food products and sludge [1]. But drying also occurs under natural conditions [2]. Mortar is submitted to natural drying when air parameters of its surrounding are changing. Drying can lead to the appearance of shrinkage, deformations and cracks, as it is reported in many studies [3]. Therefore the knowledge of the micro-structural changes and the interaction between water and solid, during drying process, is one of the keys for durability studies of cementitious material. So, deep studies dealing with moisture transfers during the process could be necessary to have a viable material.

MATERIALS

Mortars

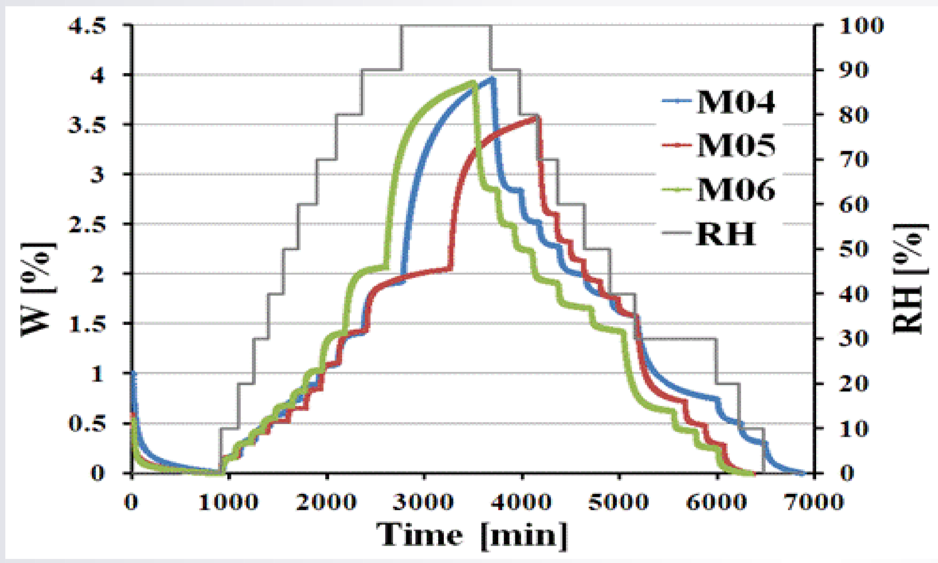
Compon--ents	References	Portions (g)		
		M04	M05	M06
Cement	CIMI-525R HES	450	450	450
Sand	referenced CEN	1350	1350	1350
Water	Tap water	180	225	270
(W/C)	Water cement ratios	0,4	0,5	0,6
(S/C)	Sand cement ratios	3	3	3

Table 1. Mix proportions of mortars

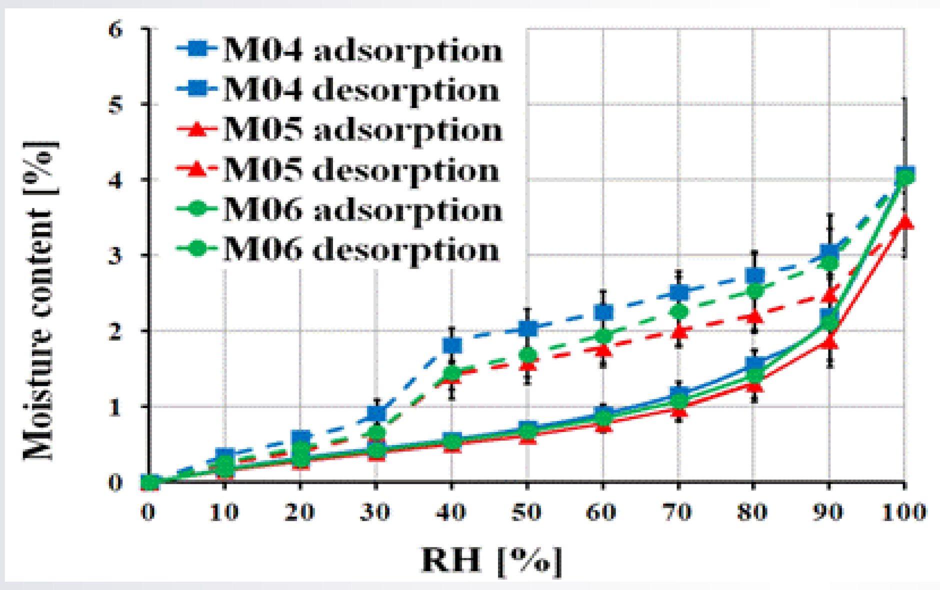
METHODS

Dynamic vapor sorption DVS

Sorption isotherms of mortar were determined using the DVS (dynamic vapor sorption), a well-established technique for the study of the interaction of water molecules with porous media and of moisture transfer in general. .



Changes in moisture content of mortar M04, M05 and M06 with the variable RH levels over the time during isotherm sorption runs at 20°C



Isotherm sorption cycle of mortars M04, M05 and M06 at 20°C

Global Moisture diffusivity «Dm» from the kinetics of water vapor sorption

- Global moisture diffusivity is obtained from sorption kinetics obtained with DVS. The evolution of moisture diffusivity as function of relative humidity is obtained by using the simplified mathematical

Fick's second law of diffusion.

$$D_{mv} = \frac{\partial}{\partial}\left(\frac{M}{\rho R T}\right)^2 D(S)\Phi \frac{P_{vs}}{\Phi}\exp\left(\frac{M}{\rho R T}\right)$$

Crank Solution

$$D_{mv} = \frac{\partial}{\partial}\left(\frac{M}{\rho R T}\right)^2 D(S)\Phi \frac{P_{vs}}{\Phi}\exp\left(\frac{M}{\rho R T}\right)$$

Moisture diffusivity in liquid state «Dml» and in the vapor state «Dmv»

- The moisture diffusivity Dm is expressed as the sum of diffusivity in liquid state "Dml" and the vapour moisture diffusivity "Dmv"
- The transfer of liquid moisture in saturated porous media was given by

Darcy's law. The **Richards equation** (Richards, 1931) represents the movement of water in unsaturated porous solids, the liquid water saturation Sr is the equation solution.

$$D_{mv} = \frac{\partial}{\partial}\left(\frac{M}{\rho R T}\right)^2 D(S)\Phi \frac{P_{vs}}{\Phi}\exp\left(\frac{M}{\rho R T}\right)$$

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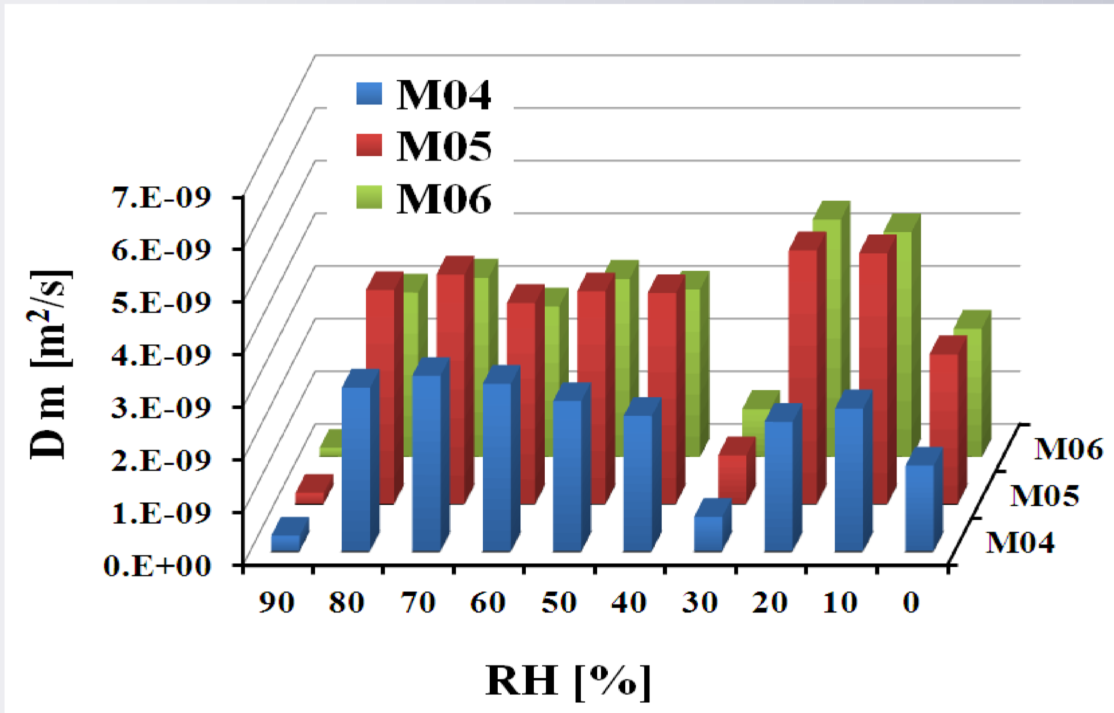
RESULTS

Fick's approach

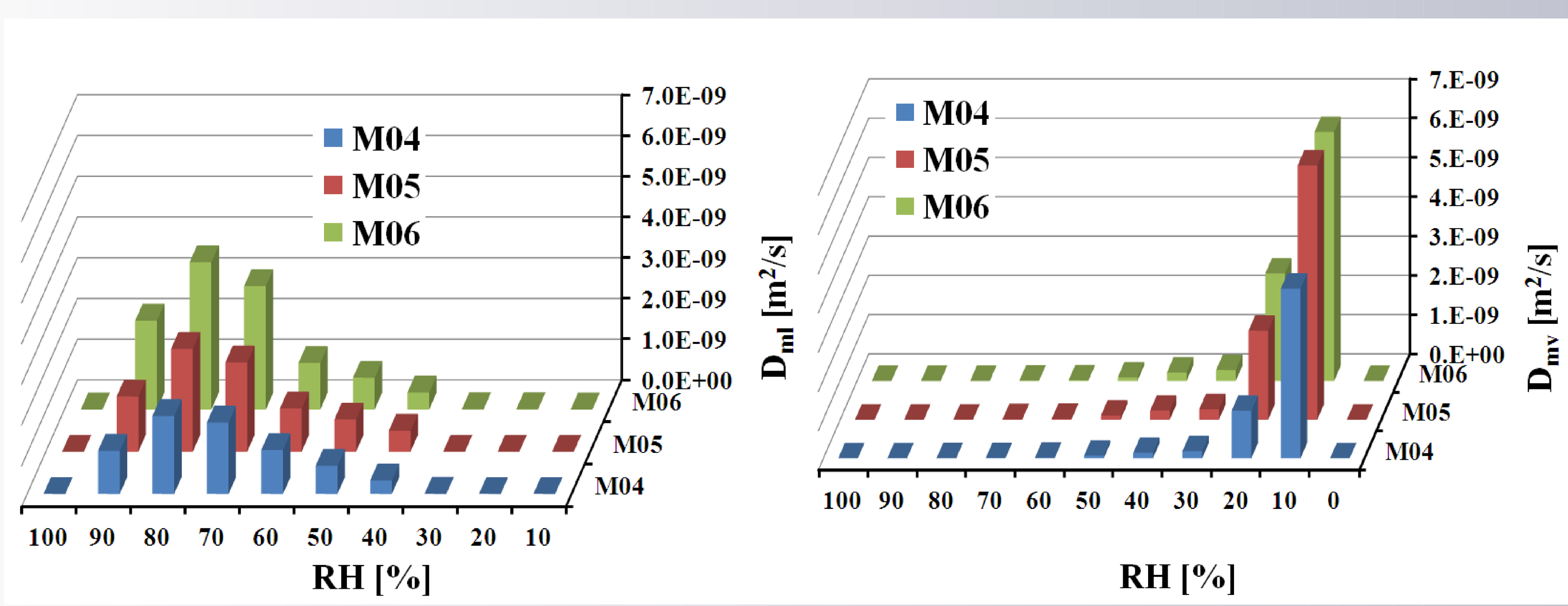
The evolution of moisture diffusivity with the water saturation degrees in desorption of the three mortars, obtained with the two methods Fick's approach



Evolution of moisture diffusivity with relative humidity obtained from desorption kinetics, for mortars M04, M05 and M06

Darcy's approach

The moisture diffusivity is obtained by the sum of water and vapor diffusivity



Liquid moisture diffusivity determined for mortars M04, M05 and M06 (on the left side) and Vapor moisture diffusivity (on the right side).

CONCLUSIONS

- Global moisture diffusivity for the three tested materials is obtained from desorption curves.
- Indeed, the evolution of the moisture diffusivity within relative humidity range is similar regardless of W/C ratio. Hence we can conclude that in adsorption increase of W/C ratio includes increasing of moisture diffusivity However for desorption relationship between W/C ratio and moisture diffusivity is not obvious. Therefore W/C ratio cannot explain alone the mortar transfer capabilities; connectivity of the very complex porous network plays an important role in the moisture transfer aptitude of the mortar.
- Based on Darcy's law we have quantified water moisture diffusivity in liquid state "Dml" and then assessed the vapour moisture diffusivity "Dmv" Thus we can determine exactly the range of relative humidity or water saturation where each mode of moisture transfer is predominant.
- As a consequence, on-going work focuses in a volume element modelling could be used, making possible to analyze the main mechanisms of moisture diffusion.

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