EXPERIMENTAL INVESTIGATION OF SORPTION ISOTHERM OF MORTAR AND MODELING OF WATER DIFFUSIVITY

L. KAHLERRAS[1], L. FRAIKIN[1], S. GERBINET[1], F. MICHEL[2], L. COURARD[2], A. LEONARD[1]

1 Department of Chemical Engineering - PEPs (Products, Environment & Processes)
University of Liege, 4000 Liege, Belgium
2 GeMMe Building Materials Laboratory, Urban and Environmental Engineering, University of Liège
- B52- Sart Tilman, Liège, 4000, Belgium

E-mail of the corresponding author: l.kahlerras@doct.ulg.ac.be

1. ABSTRACT

This work reports the results of an experimental and numerical study concerning the drying of cement mortar and specially the mechanism of moisture transfer during the process. The moister diffusivity was obtained from sorption experience, and used to simulate the internal moister transfers.

2. MATERIALS & METHODS

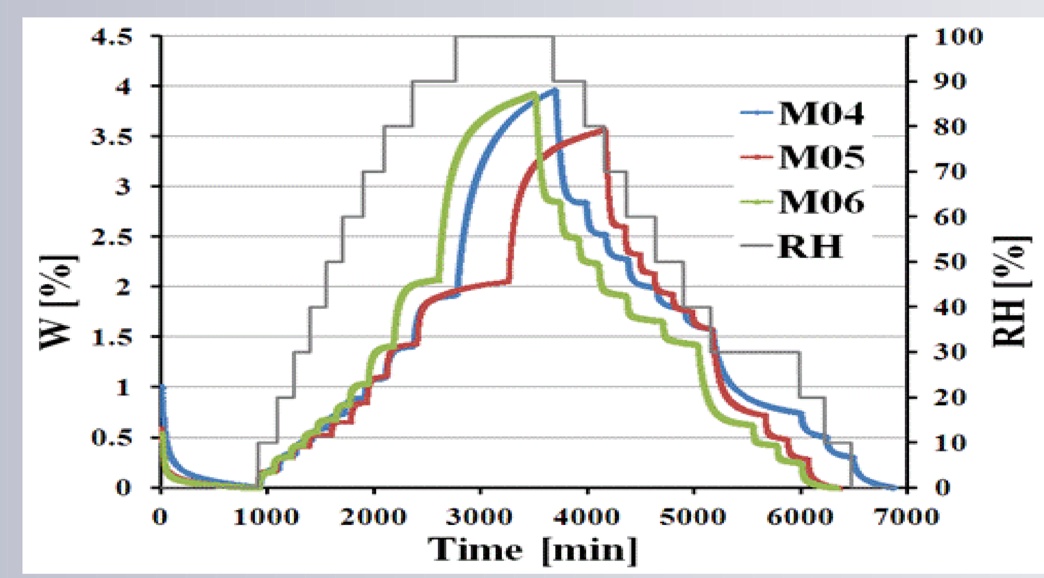
MORTARS

Components	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

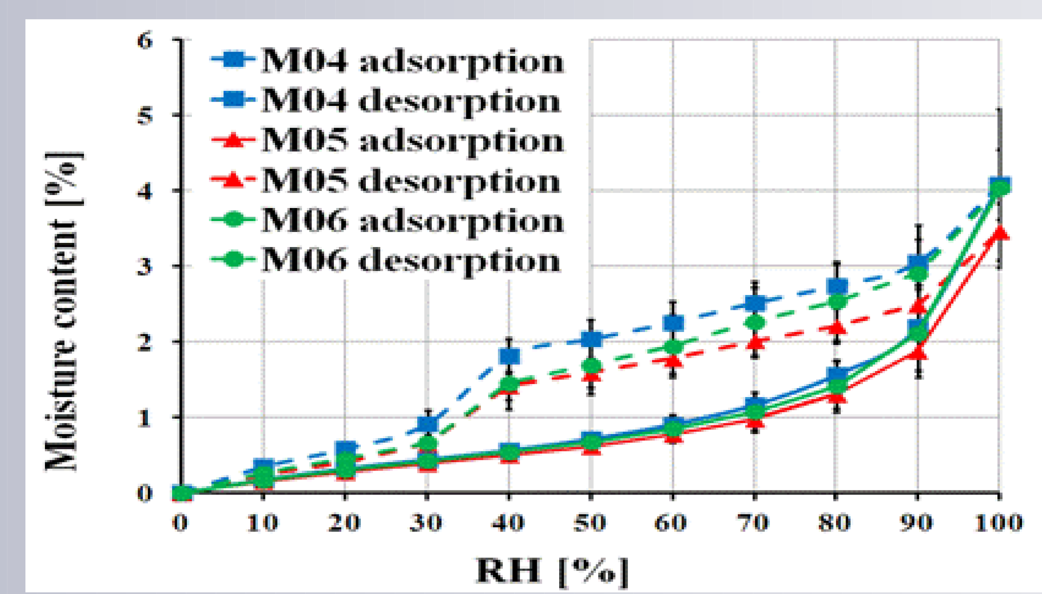
Table 1. Mix proportions of mortars

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

Fick's approach

Global moisture diffusivity **«Dm»** is obtained from sorption kinetics obtained with DVS. The evolution of moisture diffusivity as function of relative humidity is obtained by using **Crank Solution**

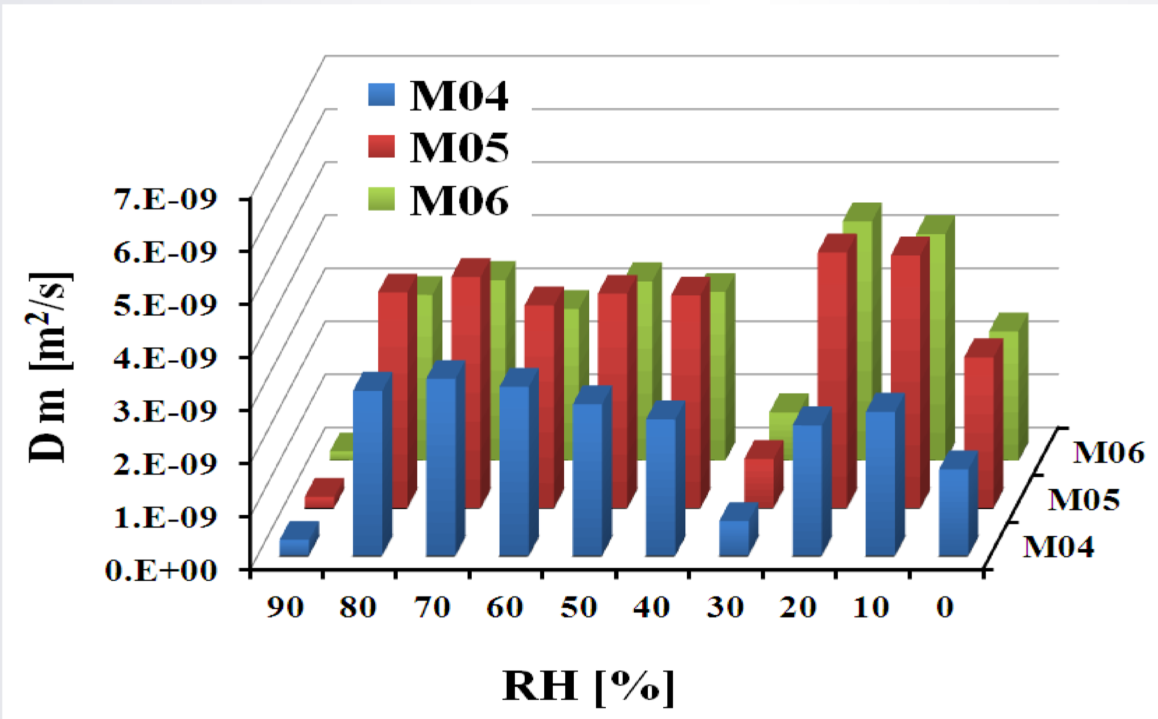
Darcy's approach

The moisture diffusivity is obtained by the sum of water $\mathbf{D_{ml}}$ and vapor $\mathbf{D_{mv}}$ diffusivity

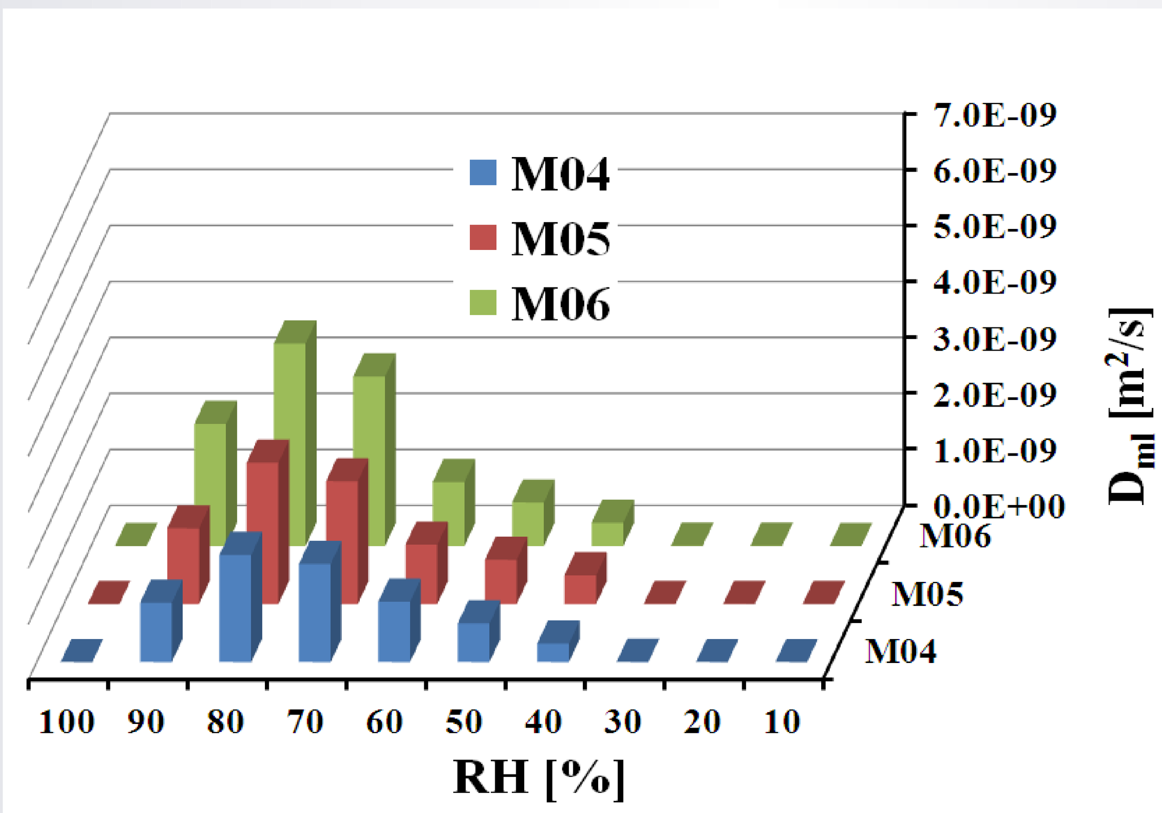
The **Richards equation** [Richards, 1931] represents the movement of water in unsaturated porous solids, the liquid water saturation Sr is the equation solution.

3. RESULTS

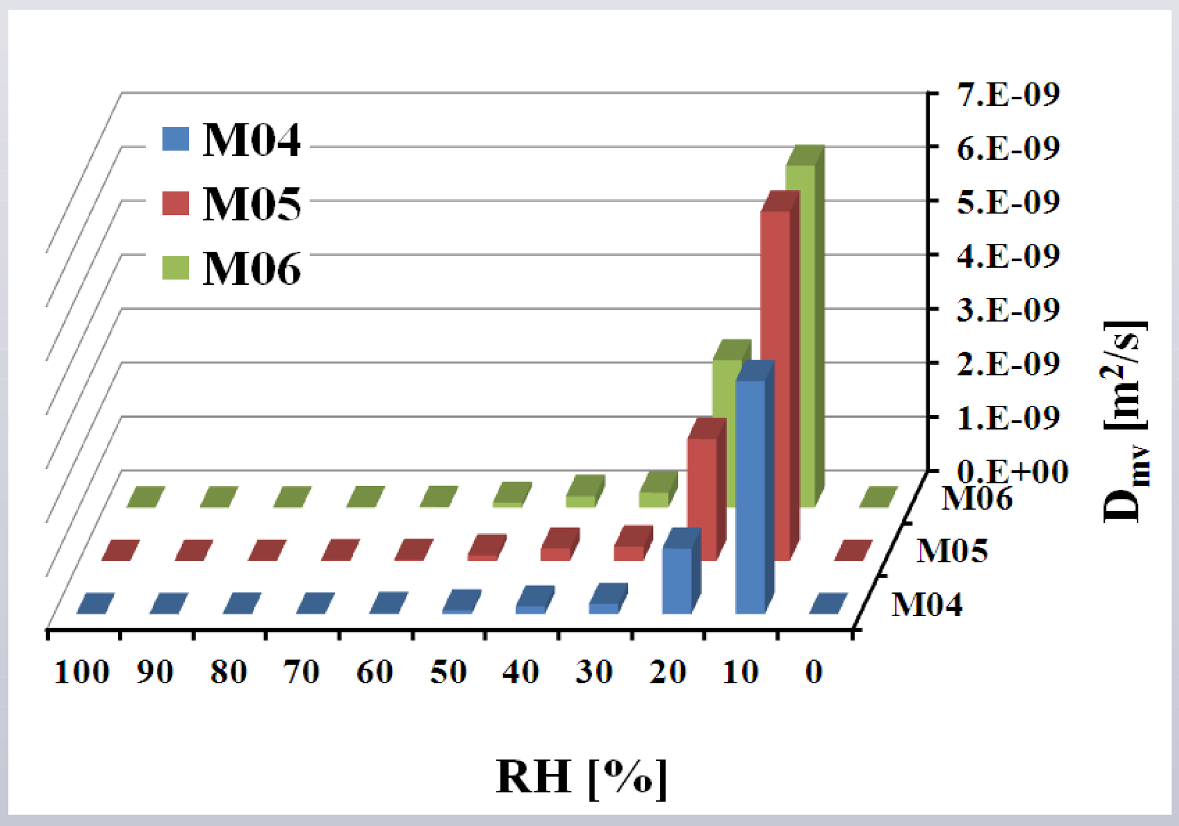
MOISTER DIFFUSIVITY OBTAINED FROM SORPTION EXPERIMENTS



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



Liquid moisture diffusivity determined for mortars M04, M05 and M06 .



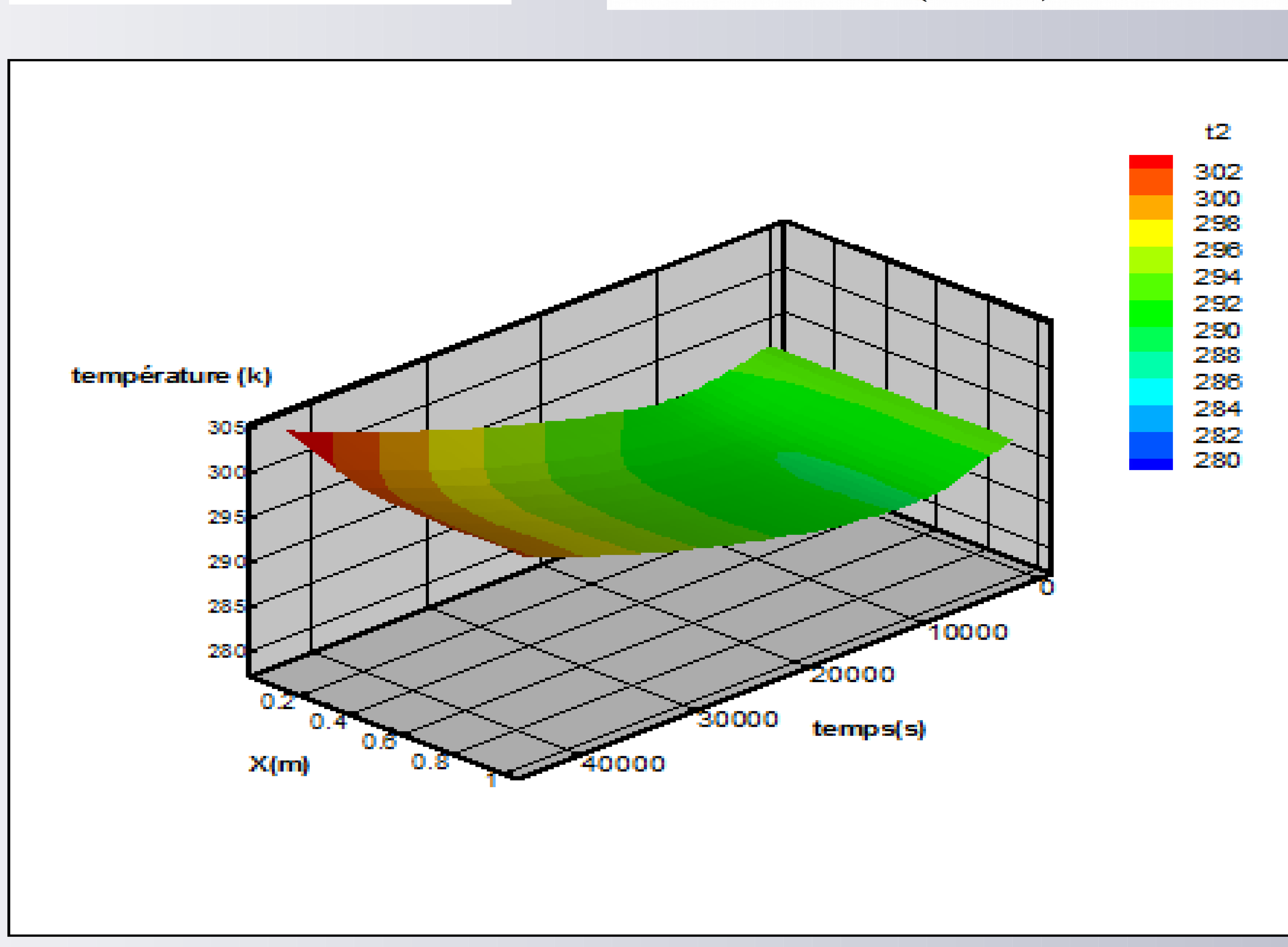
Vapor moisture diffusivity determined for mortars M04, M05 and M06.

SIMULATION

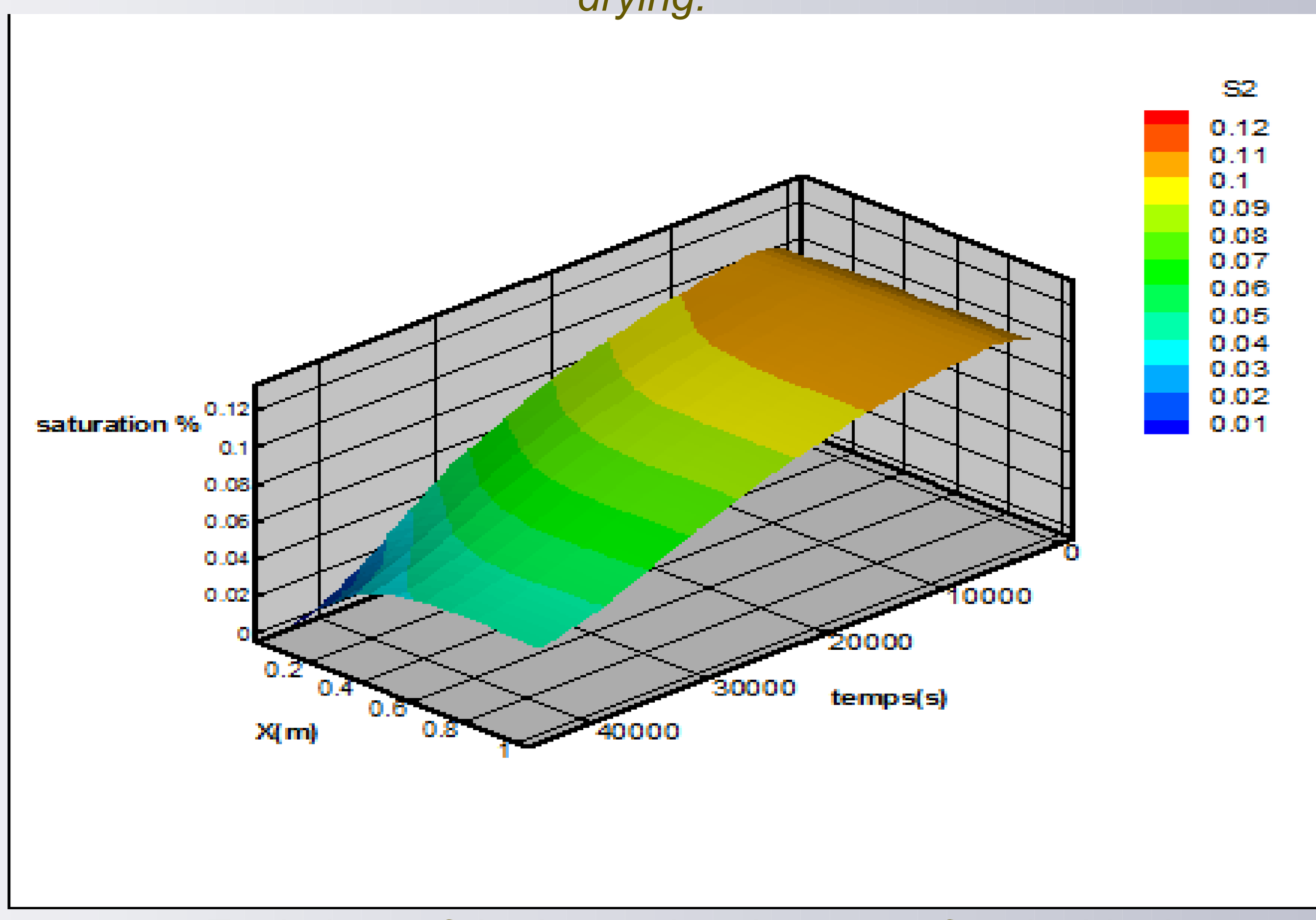
The diffusion model is used to simulate the internal heat and moister transfers during drying of mortar .

$$\frac{\partial \omega}{\partial t} = \frac{\partial}{\partial y}\left(D\frac{\partial \omega}{\partial y}\right)$$

$$\rho C_P \frac{\partial T}{\partial t} = \frac{\partial}{\partial y}\left(\lambda \frac{\partial T}{\partial y}\right) - \Delta h_v \frac{\partial \dot{m}_v}{\partial y}$$



Evolutions of the internal heat transfers inside the mortar during drying.



Evolutions of the internal moister transfers inside the mortar during drying.

4. CONCLUSIONS

- Global moisture diffusivity for the three tested materials is obtained from desorption curves.
- Based on Darcy's law we have quantified water moisture diffusivity in liquid state "Dml" and then assessed the vapor moisture diffusivity "Dmv" Thus we can determine exactly the range of relative humidity or water saturation where each mode of moisture transfer is predominant.
- focuses in a volume element modeling could be used, making possible to analyze the main mechanisms of moisture diffusion.

5. REFERENCES

[1] M. Léonard, A., Blacher, S., Marchot, P., Pirard, J., Crine, "Convective drying ofwastewater sludges: influence of air temperature, superficial velocity, and humidity on the kinetics," Dry. Technol., vol. 23, no. 8, pp. 1667–1679, 2005.

[2] V. Baroghel-Bouny, "Water vapour sorption experiments on hardened cementitious materials," Cem. Concr. Res., vol. 37, no. 3, pp. 414–437, Mar. 2007.

[3] N. Prime, Z. Housni, L. Fraikin, A. Léonard, R. Charlier, and S. Levasseur, "On Water Transfer and Hydraulic Connection Layer During the Convective Drying of Rigid Porous Material," Transp. Porous Media, pp. 47–72, 2014.