Characterization of vapour transfers in non isothermal conditions at cavities wall using convective drying tests

P. Gerard[1], A. Léonard[2], R. Charlier[1], F. Collin[1]

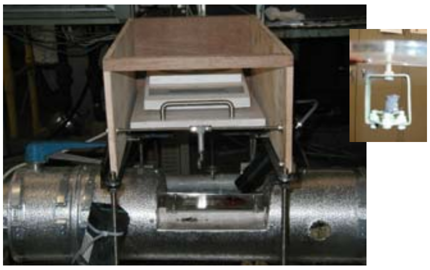
Introduction

The ventilation of the cavities excavated for radioactive waste disposals could give rise to a desaturation process of the rock mass. It could influence the development of an EDZ around the galleries. It emphasizes the need of correct heat and flow boundary conditions for modelling in order to deduce the capillary pressure distributions around the cavities. This problem can be related to the drying of an unsaturated porous medium, which is a process of moisture removal from materials. First drying tests are performed on a sandy silt, in order to adjust the procedures.

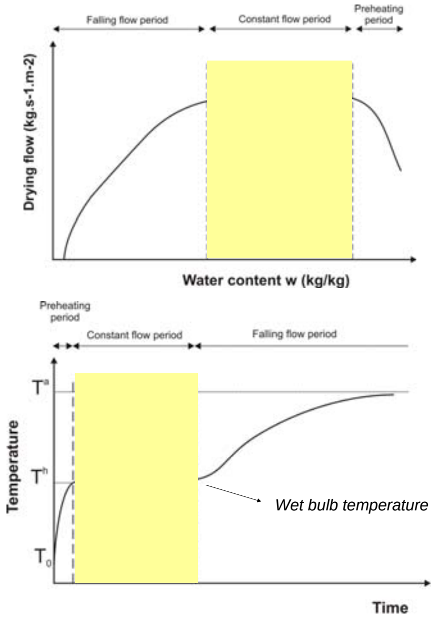
Convective drying tests

Kinetics of drying processes

Continuous weight measurement of cylindrical soil samples submitted to the convection of a humid air (controlled in temperature, relative humidity and velocity)



➔ Drying curve : $\frac{\partial M}{\partial t} - w$



Theoretical drying curve and time evolution of boundary temperature

Analyze with the assumption of the existence of a **boundary layer** all around the samples, where mass and heat transfers take place

➔ Vapour flow $\bar{q}$ and heat transfer $\bar{f}$ controlled by mass and heat transfer coefficients

$$\begin{cases} \bar{q} = \alpha\left(S_{r,w}^{\Gamma}\right).\left(\rho_v^{\Gamma} - \rho_v^{a}\right) \\ \bar{f} = L.\bar{q} - \beta.\left(T^{a} - T^{\Gamma}\right) \end{cases}$$

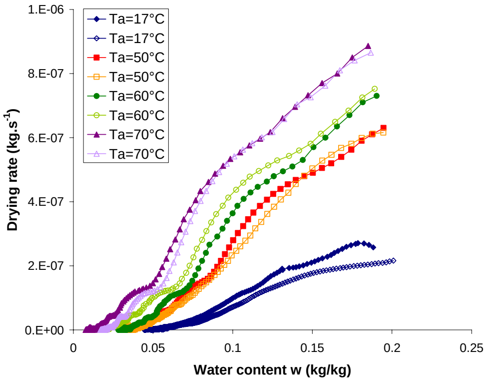
➔ Determination of the transfer coefficients during the **constant flow period** (boundary of the sample assumed saturated)

$$T = T^{h} - \rho_v^{\Gamma} = \rho_{v,0}^{\Gamma}\left(T^{h}\right)$$

$$\Rightarrow \alpha_0 = \frac{\bar{q}_{\max}}{\rho_{v,0}^{\Gamma}\left(T^{h}\right) - \rho_v^{a}}$$

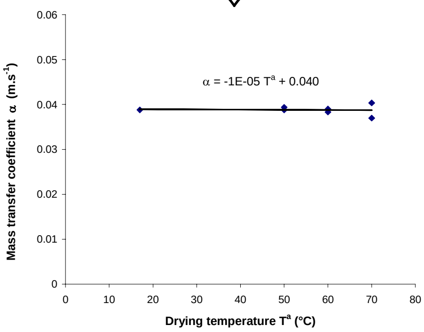
Drying tests results

First tests on Awans silt cylindrical samples (H=14 mm – R=8.5 mm) with different drying temperatures

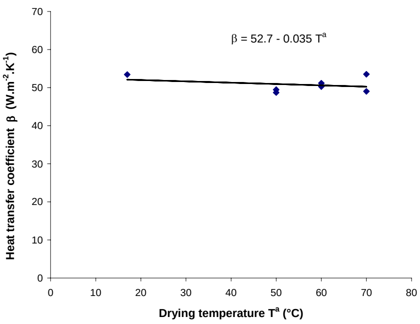


Drying curves for different drying temperatures - Air RH=1% and v=1m/s

⇓



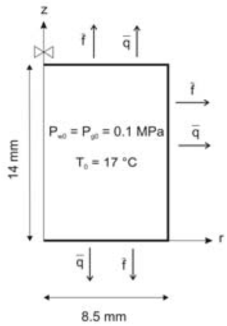
Mass transfer coefficient with drying temperature



Heat transfer coefficient with drying temperature

Drying tests modelling

- TH coupling – Axisymetrical modelling
- No mechanical influence (small shrinkage, no cracking)
- Fluid flow = Darcy's law for unsaturated case + diffusion of water vapour (Fick's law)
- Heat transport = conduction + convection + evaporation



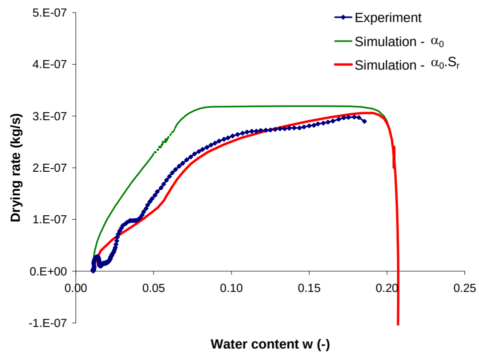
2 cases are studied:

➢ Constant mass transfer coefficient

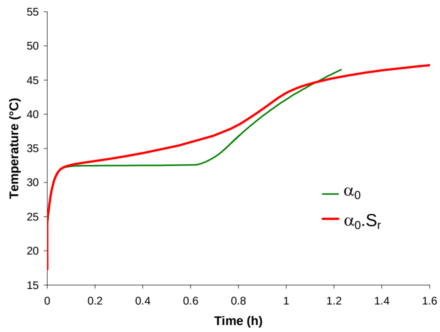
$\alpha = \alpha_0$

➢ Mass transfer coefficient vary with the saturation

$\alpha = \alpha_0 . S_{r,w}$



Experimental and numerical drying curves for a drying experiment with Tª = 50°C – RH = 30% - v = 1 m/s



Time evolution of temperature at the sample boundary

Conclusions

Assuming the influence of the desaturation of the boundary layer on the mass transfer coefficient allows a good reproduction of the kinetics of drying. The overestimation of the drying rate is avoided, which is not the case when the capillary pressure at the boundary is numerically imposed to the ambient suction. Such modelling allows the validation of the proposed formulation for the coupled flow and heat exchanges occurring at ventilated cavities wall. New series of drying tests on Boom clay are currently performed.

1 Université de Liège – Département ArGEnCo (pgerard@ulg.ac.be)

2 Université de Liège – Département de Chimie Appliquée

References: P. Gerard, A. Léonard, J.-P. Masekanaya, R. Charlier, F. Collin (2009) Study of the soil-atmosphere moisture exchanges through convective drying tests in non isothermal conditions, *International Journal for Numerical and Analytical Methods in Geomechanics*, submitted