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TECHNICAL NOTE

A POSSIBLE REVISION OF THE RESULTS OF A MODEL FOR MOISTURE TRANSPORT IN PARTIALLY SATURATED POROUS MEDIA

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ABSTRACT

It is shown that the discrepancy between the prediction of the model of van der Zanden et al. for the diffusion coefficient of liquid in porous materials and experiments can be explained with inaccuracies in the measurement of the pore size distribution or small cracks in the drying porous material.

1. Introduction

The process of moisture transport in partially saturated porous materials is not yet fully understood from a fundamental point of view. Very recently a model based on hydrodynamics has been given by van der Zanden, Coumans, Kerkhof and Schoenmakers (1995) which describes the liquid transport inside porous materials. Capillary pressure differences make liquid to move through the pores. The resistance against this movement is formed by the viscous friction modelled as in a poiseuille flow corrected with a factor F to include all effects of the deviations from the friction in the poiseuille flow. Predictions of the model were compared with experiments of water transport in clay. The model was reported to mispredict the diffusion coefficient approximately by a factor 100.

The aim of this note is to show that the misprediction of the model of van der Zanden et al. possibly can be explained by small cracks in the clay which hardly show up in the pore size distribution function but which contribute significantly to the permeability of the saturated porous material. The prediction of the model for the diffusion coefficient is very sensitive to the pore size distribution which is an input parameter in the model.

The permeability of the clay samples used in the study of van der Zanden et al. was reported to show a large scattering for different samples. This has been attributed to sample preparation. It is very well possible that a slightly different preparation of a sample results in clay with slightly different cracks in the clay which are very small compared to the resolution of the human eye. These small cracks contribute significantly to the permeability of the porous material. They can even form completely the permeability of a porous sample. In the study of van der Zanden et al. this permeability was used as an input parameter in their model. Another input parameter is the pore size distribution. Below the sensitivity of the predicted diffusion coefficient for small variations in the pore size distribution is examined.

2. Result, Conclusion and Discussion

In figure 1 two slightly different pore size distributions are given in the form of the cumulative volume fraction, C, as a function of pore radius, R, as it was reported by van der Zanden et al. for the clay used in their study. The uppermost line for which the largest pore radius is $6.0 \cdot 10^{-7}$ m [$C(6.0 \cdot 10^{-7}) = 1$] and the other which is almost identical (on this logarithmic scale) but which has a largest pore radius of $5.6 \cdot 10^{-5}$ m. The clay of the latter distribution can be regarded as having small cracks. The difference between these two pore distributions is too small to be measured using an apparatus based on mercury porosimetry. If the latter pore size distribution is used as an input parameter in the model of van der Zanden et al., it predicts a diffusion coefficient as presented in figure 2 (solid line) as a function of the volumetric moisture content, V_l/V (liquid volume V_l in a sample with volume V). Contrary to the results of van der Zanden et al. the comparison with the experimental results (squares) now shows perfect

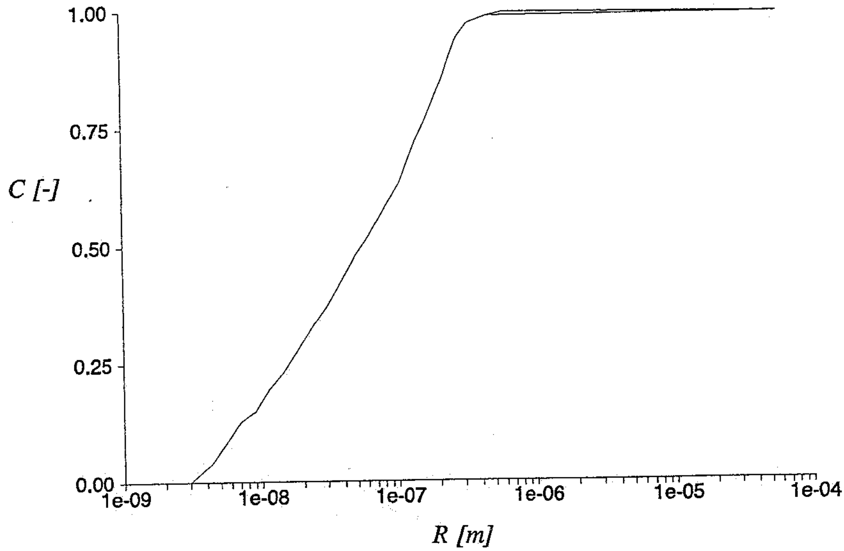

Figure 1. Two cumulative pore size distributions which vary only slightly for the largest pores.

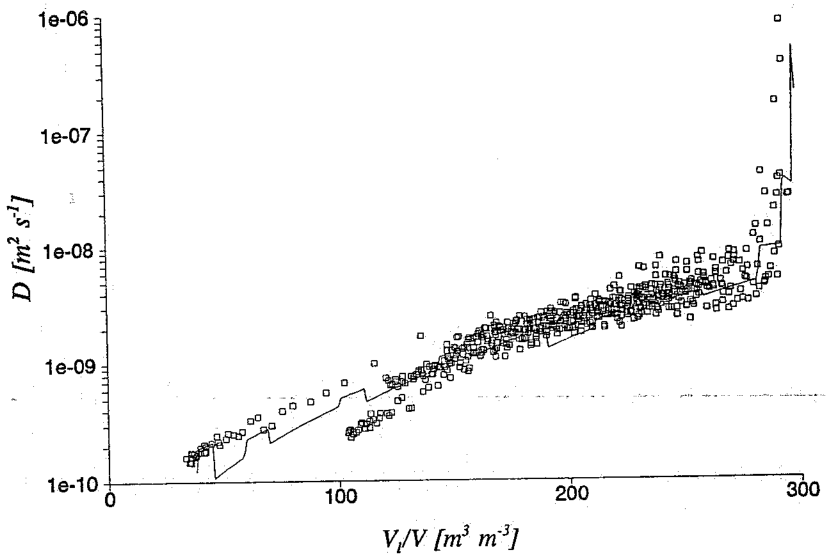

Figure 2. Comparison of the diffusion coefficient as a function of moisture content as predicted by the model (solid line) in which the pore size distribution with the cracks is used and as obtained from experiments (squares).

agreement. The good agreement for large moisture contents may be a coincidence and could also be caused by other effects such as shrinkage of the clay during drying. The correction factor F was reported to be 0.39. Using the pore size distribution with the cracks in the clay this correction factor becomes $2.1 \cdot 10^{-3}$ which seems very small. Clearly the prediction of the model for the diffusion coefficient is very sensitive for inaccuracies in the measurement of the pore size distribution. It is therefore not at all evident that the model needs some refinement which was the conclusion of the authors. It would be helpful to have some estimation for the order of magnitude of the correction factor F.

NOTATION

C	cumulative volume fraction of the pores [-]
D	diffusion coefficient [$m^2\ s^{-1}$]
F	correction factor [-]
R	pore radius [m]
V_l/V	volumetric moisture content [$m^3\ m^{-3}$]

Reference

A.J.J. van der Zanden, W.J. Coumans, P.J.A.M. Kerkhof and A.M.E. Schoenmakers, *Isothermal moisture transport in partially saturated porous media,* Drying Technology, 13(8-9).