8th. World Congress on Computational Mechanics (WCCM8)
5th. European Congress on Computational Methods in Applied Sciences and Engineering (ECCOMAS 2008)
June 30 – July 5, 2008
Venice, Italy

A MULTIPHASE APPROACH FOR A UNIFIED MODELLING OF FULLY AND PARTIALLY SATURATED POROUS MATERIALS BY CONSIDERING AIR DISSOLVED IN WATER

***Lorenzo Sanavia[1] and Dariusz Gawin[2]**

[1] Dipartimento di Costruzioni e Trasporti – University of Padua
Via F. Marzolo 9, 35131 Padova, Italy
lorenzo.sanavia@unipd.it
www.dic.unipd.it

[2] Department of Building Physics and Building Materials - Technical University of Lodz
Al. Politechniki 6, 90-924 Lodz, Poland
gawindar@p.lodz.pl

Key Words: *Poromechanics, multiphase porous material, Thermo-Hydro-Mechanical model, saturated-unsaturated transition, air dissolution in water, water cavitation, strain localization.*

ABSTRACT

A unified mathematical and numerical model for the hydro-thermo-mechanical behaviour of multiphase porous medium is developed to analyze saturated/unsaturated porous media considering the effects of air dissolved in water.

In particular, we extend here the model of coupled heat and mass transport in fully and partially saturated soils [1], which considers in a simplified way the air dissolved in pore water and air mass sources during its desorption at lower water pressure, taking also into account the dissolved air transport. This allows us to deal in a unified way both with fully and partially saturated media, without any additional, unphysical assumptions, like for example the existence of a ‘residual gas saturation’, or the application of a special numerical ‘switching’ procedure during fully-partial saturation transient [2].

To this end, the mathematical model for non-isothermal multiphase porous media is derived at macroscopic level following Hassanizadeh and Gray 1979 and Schrefler 2002. The balance equations are discretized in space and time within the finite element method for coupled problems. Small strains and quasi-static loading conditions are assumed.

Different numerical techniques used for modelling the transition between fully and partially saturated state in porous materials are discussed, and two numerical examples are solved to show both robustness of the proposed mathematical model and the method for its numerical solution. They also analyze the effect of the dissolved air released on evolution of transport processes in fully saturated geomaterials, during slow and very fast desaturation. The first example simulates the Liakopoulos experiment (water outflow, due to gravity, from the bottom of a 1-m sand column, during transient from fully to partially saturated state). The second one deals with the initiation and progress

of cavitation phenomenon during strain localization in globally undrained initially water saturated dense sands.

It is shown that taking into account the air dissolved in water and its' desorption at lower pressure has a small influence on the validity of the results obtained with multiphase porous media models, but improves significantly the numerical performance of a computer code.

REFERENCES

[1] D. Gawin and L. Sanavia, "Modelling of cavitation in water saturated porous media considering effects of dissolved air", *Transport in porous media*, (submitted).

[2] D. Gawin and B.A. Schrefler, "Thermo- hydro- mechanical analysis of partially saturated porous materials", *Engineering Computations*, Vol. **13**(7), pp. 113-143, (1996).

[3] M. Hassanizadeh and W.G. Gray, "General conservation equations for multi-phase system: 1. Averaging technique", *Adv. Water Res.*, Vol. **2**, pp. 131-144, (1979).

[4] B.A. Schrefler, "Mechanics and Thermodynamics of Saturated-Unsaturated Porous Materials and Quantitative Solutions", *Applied Mechanics Review*, Vol. **55**(4), pp. 351-388, (2002).