# Homogenization of mesoscale discrete model for poroelasticity

**Jan Eliáš[*] and Gianluca Cusatis[†]**

[*] Institute of Structural Mechanics
Brno University of Technology
Veveří 95, 602 00 Brno, Czech Republic
e-mail: jan.elias@vut.cz

[†] Department of Civil and Environmental Engineering
Northwestern University
2145 Sheridan Road, Evanston, IL 60208-310, USA
e-mail: g-cusatis@northwestern.edu

## ABSTRACT

Reliable computational models of concrete relies often on detailed representation of mesostructure (aggregate, matrix, pores, interfaces) and are therefore extremely computationally demanding. The contribution uses discrete mesoscale models of concrete where each rigid particle of the model corresponds to one larger mineral aggregate and contacts represent matrix between them. Even such efficient mesosctructure representation results in a computational burden whenever larger material volumes need to be simulated.

Rezakhani and Cusatis [1] developed homogenized description of such model to be used at macroscale via asymptotic expansion homogenization. This computational homogenization technique replaces macroscopic constitutive relations by "virtual experiment", each macroscopic integration point is connected to some representative volume element (RVE) where detailed discrete model is loaded by macroscopic strain quantities, analyzed and provides corresponding macroscopic stresses.

Motivated by excellent result of the discrete models in simulations of coupling mechanics and transport [2, 3, 4], we now extend this homogenization for the coupled model. The present contribution is limited to poroelasticity, but it will be soon extended to full nonlinear poromechanics. The originally coupled mesoscale model breaks down in homogenization into independent system of two RVEs. One RVE is purely mechanical, the second RVE is used for transport. Coupling terms binding these two RVEs together appear at the macroscale only.

The contribution presents the mathematical derivation of the homogenization and simple example of Terzaghi's consolidation verifying the developed equations.

## REFERENCES

[1] R. Rezakhani and G. Cusatis, "Asymptotic expansion homogenization of discrete fine-scale models with rotational degrees of freedom for the simulation of quasi-brittle materials," *Journal of the Mechanics and Physics of Solids*, vol. 88, pp. 320–345, 2016.

[2] H. Nakamura, S. Worapong, R. Yashiro, and M. Kunieda, "Time-dependent structural analysis considering mass transfer to evaluate deterioration processes of RC structures," *Journal of Advanced Concrete Technology*, vol. 4, no. 1, pp. 147–158, 2006.

[3] P. Grassl, "A lattice approach to model flow in cracked concrete," *Cement and Concrete Composites*, vol. 31, no. 7, pp. 454–460, 2009.

[4] P. Grassl and J. Bolander, "Three-dimensional network model for coupling of fracture and mass transport in quasi-brittle geomaterials," *Materials*, vol. 9, no. 9, 2016.