Homogenization of discrete model for fluid transport in porous material

J. Eliáš[a*] and G. Cusatis[b]

[a] Brno University of Technology, Faculty of Civil Engineering, Brno, Czechia
[b] Northwestern University, Civil and Environmental Engineering, Evanston, IL, USA
[*] corresponding author: jan.elias@vut.cz

Abstract:

Porous materials are commonly used in civil engineering industry. Modeling of fluid transport through them is essential for design and understanding of modern structures. Transport properties of porous material are largely influenced by its mechanical state, particularly cracking. Mechanical and transport problems are therefore coupled and needs to be solved together. Among many available model types, discrete mesoscale modeling offers simple and robust tool capable to characterize cracks, their orientation and widths. Thanks to this detailed crack description, these models are ideal for the mechanical-transport coupling[1]. Unfortunately, the mesoscale nature dictates size of the discrete units in the model and brings large computational cost. Reduction of this cost can be achieved by computational homogenization.

Motivated by homogenization technique for mechanical discrete models[2], we present homogenization of the fluid transport (without coupling with mechanics). Using scale separation, the transport problem is divided into macroscopic and microscopic parts. The macroscale is homogeneous continuum with constitutive model replaced by solution of discrete Representative Volume Elements (RVE). Loading of the RVE is provided via projection of macroscopic pressure gradient into eigen pressure gradients of individual elements. Summation of the fluxes from those elements then gives macroscopic flux vector.

The solution is verified by simulating simple academic examples. Both steady-state and transient types of analyses are presented.

[1]Bolander, J. E. and Betron, S. (2004). *Simulation of shrinkage induced cracking in cement composite overlays.* Cement and Concrete Composites 26(7), pp 861–871.

[2]Roozbeh, R. and Cusatis, G. (2016). *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 88, pp. 320–345.