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Finding the Representative Elementary Volume with Hill-Mandel condition

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The foundation of homogenisation methods rests on the postulate of Hill-Mandel, describing energy consistency throughout the transition of scales. The consideration of this principle is therefore crucial in our discipline of Digital Rock Physics which focuses on the upscaling of rock properties. For this reason, numerous studies have developed numerical schemes for porous media to enforce the Hill-Mandel condition to be respected. The most common method is to impose specific boundary conditions, such as periodic ones. However, the recent study of Thovert and Mourzenko (2020) has shown that most boundary conditions still result in the same intrinsic effective physical property if the averaging is applied outside the range of the boundary layer. From this discovery, it becomes logical to question the status of Hill-Mandel condition in porous media when homogenising away from the boundary. In this contribution, we simulated Stokes flow through random packings of spheres and a range of rock microstructures. For each, we plotted the evolution of the ratio micro- vs macro-scale of the energy of the fluid transport outside the boundary layer, for increasing subsample size of our porous media. Here, we prove that we naturally recover energy consistency across scales when reaching the size of the Representative Elementary Volume (REV), which is a known condition for rigorous upscaling. Furthermore, we show that this ratio for the energy consistency is a more accurate indicator of REV convergence since the mean value is already known to be unitary, which adds to the initial advantage of not having to impose any specific boundary conditions.

Participation

In-Person

References

Thovert, J.F., Mourzenko, V.V., 2020. On the influence of boundary conditions when determining transport coefficients from digital images of heterogeneous media. Advances in Water Resources 141, 103612. doi:10.1016/j.advwatres.2020.103612.

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