Comparison of Homogenization Schemes to Periodic and Random Simulations
Laurent Charpin, Florian Thomines, Alain Ehrlacher

To cite this version:
Laurent Charpin, Florian Thomines, Alain Ehrlacher. Comparison of Homogenization Schemes to Periodic and Random Simulations. Netherlands. 2012. hal-00843902

HAL Id: hal-00843902
https://hal-enpc.archives-ouvertes.fr/hal-00843902
Submitted on 12 Jul 2013

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers. L’archive ouverte pluridisciplinaire HAL, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d’enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.
COMPARISON OF HOMOGENIZATION SCHEMES TO PERIODIC AND RANDOM SIMULATIONS

Laurent Charpin1, Florian Thomine2, and Alain Ehrlacher1
1-Université Paris-Est, Laboratoire Navier (ENPC/FMSIT/CNRS), École des Ponts ParisTech, 6-8 avenue Blaise Pascal, 77455 Marne-la-Vallée, France
2-École des Ponts, 77455 Marne-La-Vallée Cedex 2 and INRIA, MICMAC project, 78153 Le Chesnay Cedex, France

ASSessment of the efficiency of the Interaction Direct Derivative homogenization scheme by comparison to Finite Element Simulations.

Average properties

At a macroscopic scale, for a porous medium with one pore family loaded with pressures \( p \), the constitutive law writes \([1]\):

\[
\begin{align*}
\sigma &= C^{hom} \varepsilon + pB \\
\varepsilon &= -\frac{1}{2} \varepsilon^{sym}
\end{align*}
\]

Where we call \( C^{hom} \) the homogenized stiffness tensor, \( B \) the Biot coefficient, and \( M \) the Biot modulus (inverse of the usual Biot modulus \( N \)).

Simulations using FreeFem++

We create a volume with pores in a 2D plane strain model, and apply:
- external loadings
- pressure in the pores
- using periodic B.C., to determine the poroelastic constants by measurement of strain and stress averages.

Fig. 1: Elliptical inclusions on an elliptical grid, periodic simulation
Fig. 2: Circular inclusions in a random simulation

Estimates

- Mori-Tanaka: \( MT \) (Inclusion embedded in the matrix, averages computed on a domain of the same shape as the inclusion, respecting volume fractions)
- Interaction-Direct-Derivative: \( IDD \) (Convenient simplification of the generalized self-consistent scheme, in which the inclusion is embedded in the matrix atmosphere, which is embedded in the average medium \([2]\))

Aligned elliptical pores, aspect ratio 0.1

We compare random simulations \( \text{simu} \), periodic simulation with isotropic cell \( \text{perEC} \) and elliptic cell \( \text{perEE} \), to the \( IDD \) scheme with circular atmosphere and the \( MT \) scheme. The \( IDD \) is failing because some coefficient reach their bound \( (0 \) or \( 1 \)) too early. \( MT \) does not show this problem. \( IDD \) needs to be used more carefully. \( \text{perEC} \) is accurate but cannot reach high volume fractions. \( \text{perEE} \) gives unsatisfactory results at intermediate volume fractions.

Fig. 3: Two possibilities for the evolution of the aspect ratio of the atmosphere
Fig. 4: Efficiency of this modification. (\( \times \)): simulations, (\( \bullet \)): geometrical rule, (\( \cdot \cdot \cdot \)): optimized shape

The geometrical rule is less satisfactory than the optimized shape, but is simpler. We call the IDD estimate built by this modification \( IDD-A \). It is not new \([3]\).

Isotropically oriented elliptical pores, aspect ratio 0.1

Finally we compare three estimates to simulations in the case of randomly oriented pores. The results obtained with \( IDD-A \) are very satisfactory.

Conclusion

The IDD scheme, when used with adapted shapes for the atmospheres, gives good results to predict the homogenized properties of crack-like pores, whether aligned or isotropically oriented.

Acknowledgements

This work was prepared thanks to a funding from the Chaire Durabilité des Matériaux et des Structures pour l’Énergie at École des Ponts ParisTech.

References