Strains in granular materials based on microstructural kinematics

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ABSTRACT

The kinematics of granular materials involves the motion of particle centroids as well as particle deformations through contacts which can be ignored for rigid particles. These provide an underlying evolving granular microstructure [1, 2] whose changes can be averaged over the whole ensemble to obtain strains at the macroscopic level with associated boundary deformations. However, an inherent characteristic of such homogenization is that most resulting relations are not invertible due to micro-scale information being much more than macroscopic strain components.

The current paper presents a statistical procedure to express strains in granular materials as a function of micro-kinematics derived from an underlying network of cells in a Dirichlet tessellation representing the particle packing structure. Evolving microstructure, through relevant micro-variables such as local coordination number and fabric anisotropy, engender topological changes in the cells. Hence, the directional distribution of the cell volume (or area) in the tessellation can be related to macroscopic deformations.

Dirichlet tessellation networks are constructed from DEM simulations of a granular assembly subjected to a given loading history. The statistics of the local distribution of coordination number and anisotropy as well as their interdependencies is conducted. The most probable outcome of the directional cell volume distribution is then calculated analytically using fabric anisotropy and coordination number as the probability distribution functions.

A kinematic expression (bijective function) is ultimately found by integrating over the strain associated with each cell at different deformational regimes. As such, volumetric and deviatoric strains can be related to evolutions of the underlying micro-variables (coordination number and local anisotropy) under coaxial loading condition. Calculations are performed for both 2D and 3D conditions. Model prediction comparisons with DEM simulations for the 2D case are presented.

REFERENCES

[1] M. Oda and K. Iwashita, *Mechanics of Granular Materials – An introduction*, Balkema, Rotterdam/Brookfield, (1999).
[2] M. Satake. "New formulation of graph-theoretical approach in the mechanics of granular materials", *Mech. Mater.*, **16** (1-2), 65-72, 1993.